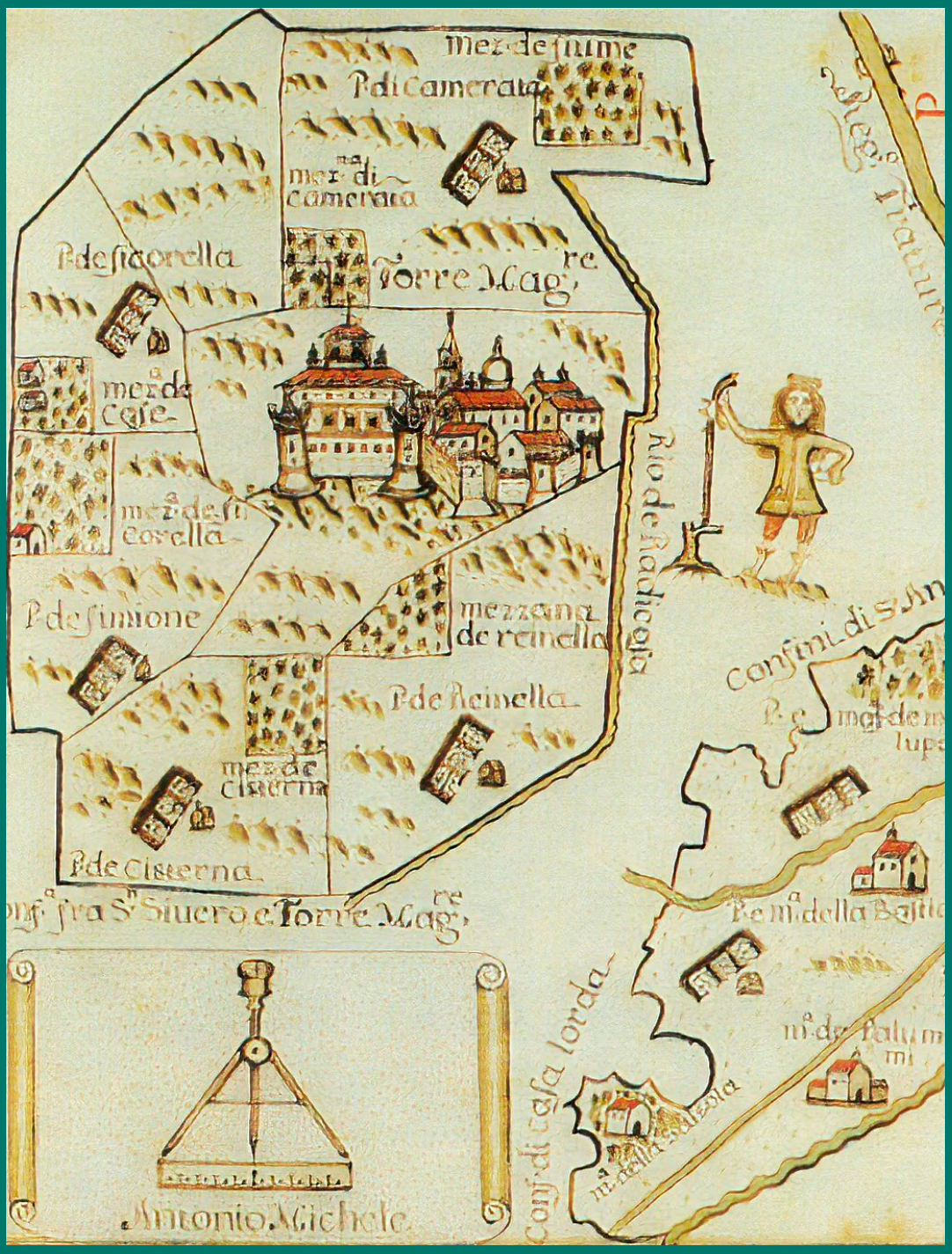
ISSN 1592-6117
www.fupress.com

AESTIMUM

CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Vol. 88 – 2026



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AESTIMUM

CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE –
Ce.S.E.T.

Vol. 88, 2026

Firenze University Press

AESTIMUM
ISSN 1592-6117 (print) |ISSN 1724-2118 (online)

Direttore Responsabile: Romeo Perrotta, University of Florence, Italy
Registrazione presso il Tribunale di Firenze n. 2875 del 17.07.1980

Versione elettronica ad accesso gratuito disponibile da: https://www.fupress.com/ceset

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com

AESTIMUM
CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Firenze University Press
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OPEN ACCESS

Citation: Andreoli, M., Gerini, F., Cozzi, M., Romano, S., Boncinelli, F., Casini, L., Marone, E., Burger, M. & Viccaro, M. (2026). Stakeholders' perceptions of factors shaping quality of life in rural areas: Evidence from two Italian case studies. *Aestimum* 88: 3-27. doi: 10.36253/aestim-18753

Received: September 25, 2025

Accepted: January 4, 2026

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Stakeholders' perceptions of factors shaping quality of life in rural areas: Evidence from two Italian case studies

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Abstract. Rural areas play a crucial role in achieving sustainable development, yet they face persistent and recurring social issues such as demographic decline, limited access to essential services, and economic stagnation. Framed on community revitalization and place-based development, this study examines the factors influencing quality of life in marginal rural areas at high risk of abandonment, focusing on Basilicata and Tuscany – two Italian regions with distinct socio-economic profiles. Adopting a qualitative approach, semi-structured interviews were conducted with local stakeholders to capture their lived experiences and perceptions of rural well-being and development opportunities. The analysis, supported by textual data processing, highlights shared and region-specific challenges. Key themes include service accessibility, demographic dynamics, economic opportunities, and governance capacity. Findings reveal that while both regions emphasize essential services and economic revitalization, their approaches differ: Basilicata stakeholders stress infrastructural deficits and demographic decline, whereas Tuscany stakeholders highlight rural diversification and place-based initiatives. These insights underscore the importance of local stakeholder perceptions in shaping rural development strategies. The study contributes to theoretical debates on rural well-being by demonstrating how stakeholder perspectives influence policy priorities and intervention strategies. It advocates for place-sensitive policies that enhance institutional capacity and leverage regional assets to promote sustainable rural community revitalization. These findings support the need for a context-specific approach to rural policy that integrates both qualitative and quantitative measures of well-being.

Keywords: well-being, inner areas, sustainable rural development, local context, place-based policy.

1. INTRODUCTION

Rural areas play a key role in achieving the Sustainable Development Goals (SDGs) established by the United Nations (United Nations, 2015). In the European Union (EU), these areas encompass 80% of the territory and accommodate 30% of the population (European Commission, 2021a). They are fundamental for food production, the sustainable management of natural resources, landscape conservation, and tourism development, significantly contributing to preserving European cultural heritage and traditions (European Commission, 2021a). Despite these assets, rural areas face considerable challenges, including globalization, urbanization, demographic decline, and population ageing, threatening rural infrastructure and services (Li et al., 2019; OECD, 2020a; Shucksmith, 2016).

To respond to these challenges, the EU has developed several initiatives and programs, such as the Common Agricultural Policy (CAP), Rural Development Programs (RDPs), the European Agricultural Fund for Rural Development (EAFRD), and LEADER program (European Commission, 2021b). These programs support sustainable agriculture, innovation, and competitiveness in the agricultural sector, protect the rural environment and landscape, and improve the quality of life (QoL) in rural areas.

The EU underscored the importance of maintaining satisfactory QoL levels in rural areas as a fundamental prerequisite for their development in the Cork Declaration 2016 (European Union, 2016). This prominence was reiterated in 2021 with the "Long-term vision for the EU's rural areas - Towards stronger, connected, resilient and prosperous rural areas by 2040" (European Commission, 2021a). The Vision leverages opportunities emerging from the EU's green and digital transitions, as well as lessons learned from the COVID-19 pandemic, to address these concerns comprehensively. This policy framework highlights the need for differentiated strategies that reflect the diversity and complexity of rural areas.

In Italy, additional measures have been mobilized through the National Recovery and Resilience Plan (RRPs), financed by the NextGenerationEU funds (European Parliament and Council, 2021). The plan includes targeted interventions to improve accessibility, digitalization, social cohesion, and innovation capacity in rural and inner areas. Within this framework, the National Center for Agricultural Technologies (Agritech) is tasked with analysing the socioeconomic determinants of development disparities and identifying the specific needs of rural communities (Ministero dell'Università e della Ricerca, 2022).

Although this topic is of significant importance, intervention strategies aimed at improving the QoL in rural areas remain limited (Casini et al., 2019). A key barrier lies in the complexity of defining and operationalizing well-being, which is inherently multidimensional and strongly context-dependent (Stiglitz et al., 2009; OECD, 2020a; Casini et al., 2021; Veréb et al., 2024). Previous studies have emphasized the importance of considering local contexts and subjective perceptions when assessing quality of life in rural and marginal areas (Scott, 2012; Shucksmith, 2016; McCrea et al.,

2016). However, empirical research based on qualitative, place-based analyses of local stakeholders' perceptions – particularly in Italian inner areas – remains limited. Addressing this gap requires a deeper understanding of lived experiences and locally grounded interpretations of well-being, which can inform more context-sensitive development strategies.

This study aims to respond to this challenge by contributing new conceptual and empirical insights to the literature on rural well-being and place-based development. This study focuses on stakeholder perceptions of well-being in inner areas of two Italian regions, Basilicata and Tuscany, defined under the National Strategy for Inner Areas (Barca et al., 2014). The research aims to investigate how key local stakeholders perceive well-being in marginal rural areas, with a focus on identifying the socio-territorial dynamics that influence current challenges and shape development opportunities. Applying a qualitative approach, the research explores the interplay between demographic trends, service provision, and territorial assets in shaping QoL. While grounded in the Italian context, the study also aims to extract broader conceptual patterns that inform the understanding of rural marginality in other European settings. In this way, it seeks to enhance the generalizability of its findings and contribute to cross-contextual theorizing on rural transformation.

The study addresses the following research questions: *i*) Which specific dimensions of well-being are perceived as most relevant by local stakeholders in Italian inner areas? *ii*) What region-specific challenges and opportunities emerge from stakeholders' narratives, and how do these reflect broader patterns of rural transformation? *iii*) In what ways do thematic clusters, such as demographic dynamics, public services, agricultural systems, and territorial governance, interact in shaping perceptions of QoL and prospects for rural development?

Through semi-structured interviews with local administrators, the study offers a qualitative exploration of these issues. The methodology enables the collection of rich, context-specific knowledge and offers detailed

insights into the governance dynamics influencing QoL in rural territories (Shucksmith and Brown, 2016). Beyond documenting casespecific dynamics, the study aims to identify recurring discursive configurations that may inform a more generalizable understanding of rural well-being. The findings contribute to the broader literature on place-based development and inform policy efforts to foster inclusive and sustainable rural regeneration.

By emphasizing stakeholder voices, this research seeks to support policies that are locally grounded. In doing so, it responds to the growing recognition that rural well-being cannot be externally imposed but must be co-constructed with local communities.

The contribution of this study lies in its ability to link grounded stakeholder perspectives with broader conceptual debates on rural well-being and governance. The empirical contribution is twofold: first, it deepens the understanding of local perceptions of QoL in inner areas; second, it identifies discursive patterns that are potentially generalizable across diverse rural contexts.

2. BACKGROUND

2.1 Marginal and inner areas

Marginal areas are territories of significant interest in terms of geography, regional development, and the formulation of policy strategies (Li et al., 2019). They become particularly crucial in countries like Italy, where geographic diversity and socio-economic development disparities pose significant challenges (Bertolini and Pagliacci, 2017). In Italy, the definition of marginal areas is associated with that of inner areas provided in the Italian National Strategy for Inner Areas, an initiative launched by the Italian government in 2014 to address issues of marginalization and promote socio-economic development in remote areas (Barca et al., 2014). In Italy, inner areas encompass 60% of the national land area, 52% of municipalities, and 22% of the population (Agency for the Territorial Cohesion, 2024). Inner areas are characterized by their considerable distance from centres offering essential services such as healthcare, education, and mobility. These areas possess a rich heritage of environmental and cultural resources and exhibit great diversity due to their intrinsic nature and centuries-long processes of anthropisation that have shaped them (Barca et al., 2014).

During the second half of the 20th century, Italy's inner areas were often regarded, particularly from sociodemographic and economic perspectives, as *shrinking regions* - marginal, declining, and contracting areas afflicted by dramatic depopulation. This phenomenon, characterized by a mass exodus, especially of young people, to urban and metropolitan areas in the plains and coastal zones, resulted in a significant demographic shift (Bertolini and Pagliacci, 2017; Mallach, 2017; Martins and Davino, 2023). The exodus was driven by the pursuit of better living conditions and propelled by industrialization and urbanization dynamics (Barca et al., 2014).

These regions face a comprehensive structural crisis marked by economic and labour market decline, peripheralization, and a widening urban-rural divide, exacerbating the inherent disadvantages of rural areas (ESPON, 2017). Additionally, shrinking inner areas experience a deterioration of rural infrastructure, a reduction in the availability of essential services, difficulties in accessing healthcare, social services, and education, as well as limitations in transport, digital connectivity, and postal and banking services (European Commission, 2024). These factors have led to negative outcomes such as higher poverty and unemployment rates compared to more developed regions, such as urban areas.

Inner areas exhibit various territorial, cultural, and social aspects that can be leveraged to foster the development of these regions (Tricarico et al., 2022). These areas are often rich in valuable natural and scenic resources, including mountains, hills, forests, and natural parks that provide opportunities for tourism, recreational activities, and biodiversity conservation. The natural heritage represents a fundamental asset that, if properly managed, can stimulate economic development and improve the QoL for residents (Sardaro et al., 2021). The cultural heritage of inner areas is equally significant, encompassing historic villages, archaeological sites, local traditions, and artisanal products (Crociata et al., 2025). These elements can drive cultural tourism and the promotion of typical products, contributing to the enhancement of local identities and social cohesion (Woods, 2006).

Inner areas offer a more tranquil and less polluted living environment compared to urban areas (Cozzi et al., 2022). The presence of green spaces, low population density, and direct contact with nature are factors that contribute to a higher QoL (Casini et al., 2021). These aspects can attract new residents, particularly families and individuals seeking a more sustainable and healthier lifestyle (Sgroi, 2022).

Social cohesion is a crucial factor for community resilience and the ability to tackle economic and social challenges.

Communities in inner areas are often characterized by a strong sense of belonging and social cohesion (Viccaro et al., 2021). This cohesive social structure facilitates collaboration and active citizen participation in local development projects (Mastronardi et al., 2020).

Agriculture represents an important component of the economy in inner areas (Boncinelli and Casini, 2014). The availability of agricultural land offers opportunities for economic development and employment (Christiaensen et al., 2021). The enhancement of local productions and the integration of agri-food supply chains can significantly contribute to the sustainable development of rural areas (Liu et al., 2022).

Recently, interest in inner areas has grown, driven by increased awareness of their potential for sustainable development and the enhancement of territorial heritage (Yin et al., 2022). The abundant natural resources, including forests, pastures, watercourses, and biodiversity, present invaluable opportunities for nature tourism and green economy activities (Barca et al., 2014). Additionally, the rich cultural heritage, characterized by centuries-old traditions, local craftsmanship, and distinctive products, provides a foundation for the development of high-quality agri-food chains and cultural tourism (Barca et al., 2014). This renewed focus on inner areas underscores their strategic importance in fostering sustainable economic growth and enhancing the QoL for their inhabitants (Marsden, 2009).

2.2 Quality of life in marginal rural areas: definitions, dimensions, and approaches

In the context of marginal rural areas, QoL has emerged as a central concern for both researchers and policymakers (Meloni et al., 2023; Veréb et al., 2024; OECD, 2020a). In territories affected by structural vulnerabilities, QoL transcends standard measures of economic performance, encompassing a broader set of material and immaterial dimensions (OECD,

2020a). The term "quality of life", often used synonymously with well-being or happiness, indicates an individual's overall satisfaction with his or her existence (McCrea et al., 2016). It is a complex and dynamic concept that varies across time and social contexts (Pontin et al., 2013), reflecting the diverse needs and experiences of local populations (Viccaro et al., 2021). It is also relative, as assessing well-being often involves comparing individuals or communities with others (Casini et al., 2021).

Among the conceptual frameworks, the capability approach offers a useful reference point (Nussbaum, 2000; Sen, 1999), highlighting the importance of assessing well-being in terms of people's effective freedoms and real opportunities to pursue the lives they value. This perspective reinforces the need for a multidimensional and context-sensitive interpretation of QoL, especially in marginal areas where structural constraints may limit individual and collective agency.

Since capabilities are context-dependent, the selection of dimensions must be adapted to each case (Nussbaum, 2000; Sen, 1999). In the Italian rural context, studies have identified key QoL dimensions including economic conditions, healthcare, education, employment, transport, safety, environmental quality, landscape, cultural heritage, social ties, and innovation (Casini et al., 2021; Viccaro et al., 2021).

Methodologically, the literature distinguishes between subjective and objective approaches to assessing well-being (OECD, 2020b; Voukelatou et al., 2021). Each offers distinct but complementary insights: subjective methods focus on personal perceptions, while objective ones rely on measurable indicators (Cummins, 2000; Stiglitz et al., 2009; Viganó et al., 2019). Subjective approaches assess individuals' satisfaction with housing, health, education, employment, and social life, typically through surveys, interviews, or focus groups (Casini et al., 2021; Contzen and Häberli, 2021; MäkiOpas et al., 2022; Vendemmia et al., 2021). Qualitative methods, in particular, capture the complexity of lived experiences (Creswell and Poth, 2017). For instance, quantitative measures might indicate generally adequate healthcare facilities in a community, yet qualitative data might reveal barriers linked to trust, culture, or accessibility (Kahneman and Krueger, 2006). These methods thus allow a richer, community-grounded understanding of QoL.

Objective approaches rely on quantifiable indicators such as income, employment, education, or life expectancy (ISTAT, 2023; OECD, 2020b). Their strength lies in standardisation and comparability across contexts (Barrington-Leigh and Escande, 2018; Veréb et al., 2024), but they may miss subjective experiences and local specificities. While indispensable for large-scale analysis, they should be complemented by more contextual tools (Frey and Stutzer, 2002).

The qualitative approach, which involves conducting interviews or focus groups with citizens and specially informed people to measure QoL, is suitable for gathering detailed data essential for identifying emerging themes and outlining key variables that may influence the QoL in the communities under study (Makri and Neely, 2021).

In this regard, our study, based on a qualitative approach through interviews with mayors, offers significant advantages. First, mayors represent a privileged point of observation, as they possess both institutional knowledge and direct experience of the everyday challenges faced by their communities. As the leading figures of local authorities, they are entrusted with responsibilities across social, environmental, and economic domains, dimensions that closely intersect with QoL.

Their narratives provide valuable and privileged points of view into the interplay between structural constraints and local resources, and into the perceptions of what constitutes a "good life" in marginal areas. Second, the qualitative method allows for flexibility and depth, capturing place-specific understandings of QoL that are often overlooked by standardized metrics. Finally, this approach aligns with the capability perspective, enabling a contextualized and peoplecentred reading of well-being that is sensitive to the values, priorities, and aspirations of local populations.

3. CASE STUDIES AND METHODOLOGY

3.1 Methodological approach and research design

This study adopts a qualitative methodology with an exploratory purpose. The research design is guided by three general research questions formulated to analyze the relationship between quality of life, local governance, and conditions of territorial marginality. These questions are intentionally broad to capture the complexity of the social, institutional, and territorial processes under analysis. The aim is to investigate the perceptions of key local stakeholders regarding the factors that influence QoL in rural areas. This choice, grounded in a bottom-up logic, is driven by the need to capture direct experiences and socio-cultural nuances often overlooked by top-down quantitative approaches (Corbetta, 2015). This approach is particularly suited for understanding human experiences within their natural context and for building theory directly from data (Creswell & Poth, 2017; Sutton & Austin, 2015). The instrument for data collection was the semi-structured interview, selected for its capacity to ensure both flexibility in inquiry and comparability across data sets. As highlighted by Hijmans and Kuyper (2020), this technique relies on a thematic guide and open-ended questions, allowing the conversational path to be adapted while ensuring investigative depth. The interview protocol (see Appendix), composed of 13 questions, was developed from the key points emerging from a previous study by Casini et al. (2021) regarding viability and well-being in marginal areas. These dimensions were used to operationalize the research questions through a contextualized adaptation of empirical evidence, specifically calibrated for mayors of inner areas in Basilicata and Tuscany. Rather than a one-to-one correspondence, each of the three research questions is explored through a set of complementary questions, ensuring coherence between the theoretical framework, research questions, and data collection instruments. Specifically, the interview protocol explored dimensions of rural life (Meloni et al., 2023) such as accessibility and satisfaction with services (e.g., education, healthcare, transportation, tourism), social cohesion and safety, environmental quality and territorial strengths, challenges faced by specific demographic groups (e.g., youth, women, immigrants), issues in agricultural activities, strategies to address depopulation, and opportunities for public funding and sustainable development. The interviews were conducted online between May and September 2023, each lasting 50–60 minutes, and were audio-recorded with informed consent.

3.2 Case studies and sample

The case selection is guided by a comparative logic and a maximum variation sampling strategy. The objective is to include territories with differing socio-economic and morphological conditions, which are nonetheless united by their shared classification under the National Strategy for Inner Areas (NSIA) 2021–2027.

In particular, the analysis focus on specific inner areas of Basilicata and Tuscany, two Italian regions characterized by distinct geographical, demographic, and socio-economic profiles. The selection of these regions is also driven by their explicit inclusion in the PNRR Agritech project, which targets rural innovation and development in selected areas of Southern and Central Italy. By examining these contrasting case studies, the research aims to identify key challenges and factors affecting QoL of rural communities. This serves as a starting point for defining specific approaches to investigate QoL dimensions in greater depth and offering policy recommendations to enhance rural development and improve QoL.

Basilicata and Tuscany (Figure 1) were selected for their rural landscapes and socio-economic structures. Basilicata, located in southern Italy, is predominantly rural (OECD, 2020b), with 72 municipalities classified as peripheral or ultraperipheral by the National Strategy for Inner Areas (NSIA) 2021-2027. The region faces significant challenges, including population aging, depopulation, and limited economic development, making it a vital case for studying rural marginalization (Viccaro et al., 2015, 2021).

The seven Basilicata's inner rural areas (Alto Bradano, Montagna Materana, Marmo Platano, Mercure - Alto Sinni - Val Sarmento, Medio Agri, Medio Basento, Vulture) highlight both socio-economic difficulties and opportunities for endogenous development. Tuscany (central Italy), in contrast, offers a more diversified rural environment across its ten provinces. The NSIA 2021-2027 identifies six inner areas (Casentino - Valtiberina,

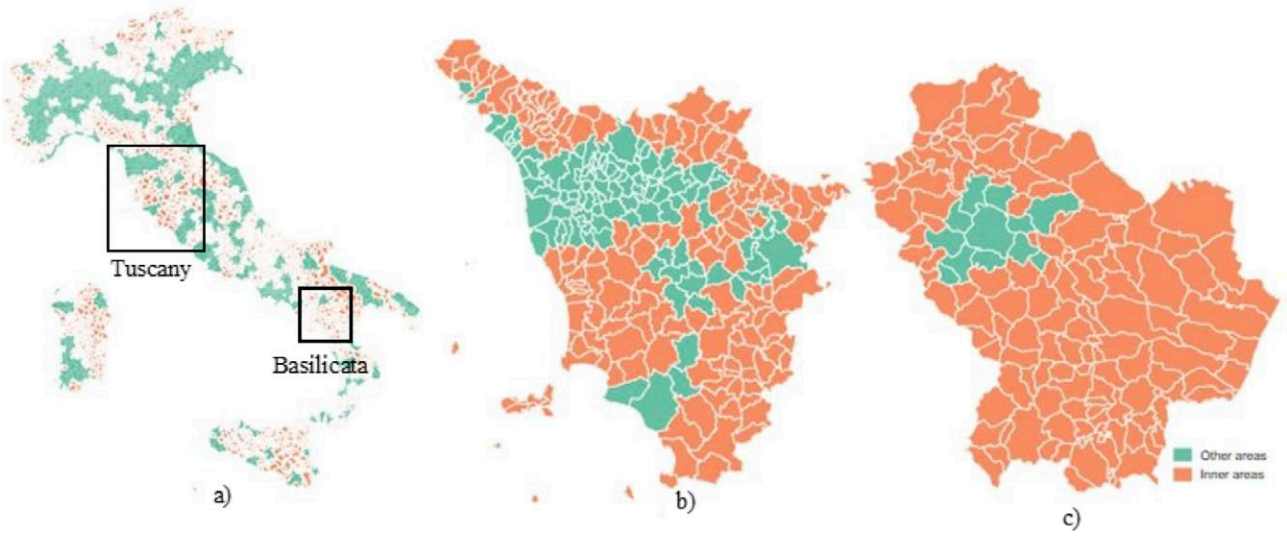

Figure 1. Inner areas in Italy (a), Tuscany (b), and Basilicata (c).

Garfagnana - Lunigiana - Media Valle del Serchio - Pistoia Apennines, Valdarno - Valdisieve - Mugello - Val Bisenzio, Amiata Grossetana - Amiata Val d'Orcia - Colline del Fiora, Alta Valdera - Alta Val di Cecina - Colline Metallifere - Val di Merse, Valdichiana Senese), encompassing 164 municipalities classified as intermediate, peripheral, or ultra-peripheral. Tuscany's rural complexity, rooted in its natural resources, cultural heritage, and socio-economic infrastructure, provides insights into QoL dynamics (Casini et al., 2018). Together, these regions enable a comparative analysis of local administrators' perspectives regarding rural well-being and sustainable development.

This study employed a purposive sampling strategy aimed at engaging institutional stakeholders who could offer both a strategic and an operational perspective on local dynamics. All mayors of the municipalities classified as peripheral and ultra-peripheral (NSIA, 2021-2027) in the two regions under consideration were contacted, along with the Presidents of National Association of Italian Municipalities (NAIM) Tuscany and Basilicata, via official emails requesting their participation in a qualitative interview. The final sample consists exclusively of those who expressed their availability to participate, thus constituting a self-selected sample from the target population of local decision-makers. No ex-ante selection criteria were applied other than institutional status and geographical location. Specifically, in Basilicata, four mayors and one President of Unions of Municipalities, who also serve as mayor, were interviewed. In Tuscany, the sample comprises three local administrators from the Tuscan-Emilian Apennines area, one Vice President of Unions of Municipalities, who also serve as mayor and the President of NAIM Tuscany. Although the sample is not statistically representative, it is nonetheless consistent with the exploratory objectives of qualitative research, as it consists of individuals directly involved in decision-making and territorial management processes. This composition ensures qualified institutional representation and allows for a comparison between two different ideas of rural governance, which is useful for uncovering local perceptions, priorities, and strategic visions. A summary overview of the sample composition, including ID (MB means mayor of Basilicata and MT means mayor of Tuscany), role, and geographical origin, is provided in following Table 1.

The decision to involve mayors does not stem from the assumption that their viewpoint is the most relevant

Table 1. Sample composition.

ID	Role	Location
MB_01	Mayor	Basilicata
MB_02	Mayor	Basilicata
MB_03	Mayor and President of Union of Municipalities	Basilicata
MB_04	Mayor	Basilicata
MB_05	Mayor	Basilicata
MT_01	Mayor	Tuscany
MT_02	Mayor	Tuscany
MT_03	Mayor and Vice President of Union of Municipalities	Tuscany
MT_04	Mayor	Tuscany
MT_05	President of NAIM Tuscany	Tuscany

among all stakeholders, but from the recognition that they are among the most representative figures for their territory, in their capacity as "first citizens" and spokespersons for the local population. Furthermore, they are key actors in local change, as they directly lead the processes of planning, management, and administrative innovation, particularly in peripheral contexts where local government plays a crucial role in ensuring the provision of services and attracting resources for development (Viccaro, 2021).

3.3 Data analysis and methodological tools

The analysis of the empirical material was designed to combine the depth of qualitative interpretation with the efficiency of computational methods by tools for textual analysis. This approach aimed to identify recurring themes, relational patterns, and semantic structures emerging from stakeholders' narratives, while maintaining strong adherence to the original discourse (Chaves et al., 2017; Ratinaud, 2008).

The transcriptions were carried out using an open coding approach (McLeod, 2024), according to the Grounded Theory Method (Glaser and Strauss, 1967), based on a word-by-word and event-by-event logic, to maximise fidelity to the participants' expressions and to enable the emergence of meaningful interpretative cues (Tarozzi, 2008). This detailed and unfiltered transcription ensured that the subjective nuances of each interviewee's narrative were retained as input for the subsequent stages of text processing and analysis.

For example, the following segment from interview MT_01*: "The young people I see around here are more interested in niche products linked to production and baking, such as ancient grains, chestnut flour and desserts made with chestnut flour and potatoes..."*. Was coded as: youth entrepreneurship, agricultural innovation, niche production. Another example, from interview MB_01*: "We have two main urban centres more than 18 km apart... we have the same human resources as an average municipality but we have to manage twice as much*". Was coded as: infrastructure duplication, administrative fragmentation, human resource strain.

The transcripts were further processed using IRaMuTeQ (Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires) software, version 0.7 alpha 2, developed by Pierre Ratinaud (2008).

The IRaMuTeQ software was chosen because it supports a systematic and comparative textual analysis aimed at a multi-level understanding of stakeholder perceptions (Rodríguez et al., 2024, Mendes et al., 2016; Souza et al., 2018). Its primary strength lies in applying quantitative methods to qualitative data, thus enriching the interpretation with statistical evidence without sacrificing the depth of the original discourse (Camargo & Justo, 2013; Lahlou, 2012). Furthermore, its suite of integrated tools ensures methodological coherence across all phases of the analysis (Ratinaud, 2008; Mennani & Attak, 2024).

The analysis employed a multi-phase process using several of IRaMuTeQ's analytical tools to compare perceptions across Basilicata and Tuscany. Initially, we conducted an exploratory analysis using a word cloud and similarity analysis to identify core concepts and reveal their underlying connections, effectively mapping the stakeholders' discourse (DePaolo & Wilkinson, 2014; Bletzer, 2015; Segev, 2022). Following this, we applied Descending Hierarchical Classification (DHC) to inductively group the text into coherent thematic clusters. Finally, the robustness of this thematic structure was statistically validated with Confirmatory Factor Analysis (CFA), which confirmed the consistency and differentiation of the clusters (Brown, 2015; Mishra, 2016). This structured approach enabled a detailed, comparative analysis of perceptions of rural well-being.

For this study, the interview transcripts were transformed into two different corpora representing stakeholders from Basilicata and Tuscany: each corpus of analysis included five interviews, known as an Initial Context Unit - ICU (Souza et al., 2018), for each region. These corpora were then analysed using word cloud visualization, similarity analysis, DHC and confirmatory factor analysis (CFA) (Camargo and Justo, 2013; Castro et al., 2014). To ensure data integrity, only "full" language elements - adjectives, nouns, verbs, and auxiliary forms - were retained during corpus preparation, enriching the content, and enhancing the depth of analysis. Corpus preparation involved standardizing acronyms, correcting typographical errors, and adjusting composite words (e.g., "wild_animals" or "hydrogeological_instability") to ensure consistent processing.

It is important to point out that, in adherence to the methodological principles of the Grounded Theory, the interviews were analysed and subjected to textual analysis in their original language (Italian) without any modifications. This decision is consistent with established practices in the existing literature (i.e., Karim et al., 2024; Chaves et al., 2022; Galli & Fasanelli, 2020; Souza et al., 2018), which frequently employs the IRaMuTeQ software for the textual analysis of interviews, favouring the use of texts in their original language.

The analysis revealed core themes influencing rural well-being in Basilicata and Tuscany, highlighting shared and region-specific perspectives. The methodological steps provided a detailed understanding of rural

well-being, offering actionable insights for addressing challenges and promoting sustainable development in rural areas.

4. RESULTS

The findings presented in this section are derived from semi-structured interviews with 10 mayors from the two case study areas. Although this sample is not statistically representative, as previously noted, the analysis holds significant validity. It reflects the perspective of key institutional actors whose political and administrative vision constitutes the primary source of the data analyzed.

4.1 Word cloud and thematic coding

The application of IRaMuTeQ software facilitated the creation of word clouds, a technique that aggregates words and organizes them graphically based on their frequency in the text. Words that appear more frequently are displayed in larger sizes, offering a visually engaging and straightforward method for identifying key themes in the qualitative data. The generated word clouds highlighted recurring issues raised by the stakeholders (Figure 2). and represent a first level of exploration of the textual data. Furthermore, to enrich the understanding of the underlying meanings, a qualitative thematic coding was carried out based on the full texts (Table 2).

The coding followed an inductive and iterative approach (Thomas, 2003), which allowed us to identify the main thematic areas and semantic interconnections between concepts. The most significant themes were organised into main categories and subcategories, as shown in the Table 2.

Table 2. Thematic coding.

Thematic Code	Key Issues
Essential services	Schools, healthcare, local public transport
Human resources	Staff shortages, NEETs, turnover
Territorial development	Tourism, agriculture, circular economy
Structural vulnerabilities	Hydro-geological instability, isolation, bureaucracy
Demographics and population	Depopulation, birth/death rate, immigration
Governance and administration	Union of municipalities, PNRR funds, inland area planning

This structure has made it possible to interpret word clouds not only in terms of frequency, but as a visual representation of a complex network of meanings, consistent with territorial narratives.

Common themes across both Basilicata and Tuscany included terms such as territory (*territorio*), municipality (*comune*), citizen/people/population (*cittadino/persona/popolazione*), agriculture (agricoltura), human capital (*risorse umane*), essential services (*servizio/servizi essenziali*), tourism (*turismo*), and hydro-geological instability (*dissesto idrogeologico*).

Distinctive regional differences were also evident. In Basilicata, terms such as depopulation/demographic decline (*spopolamento/calo demografico*), green community, scattered houses phenomenon (*fenomeno delle case sparse*), union of municipalities (*unione dei comuni*), and innovative school (*scuola innovativa*) emerged prominently. In contrast, Tuscany featured terms such as population growth/positive population rate (*crescita demografica/tasso popolazione positivo*), forest (*bosco*), mountains (*montagne*), local public transport (*trasporto pubblico locale*), and 1€ houses project[1] (*progetto case a 1€*).

Although word clouds effectively highlight significant terms, they do not capture the underlying complexities behind these terms.

To explore the meaning of these concepts in greater depth, a qualitative thematic coding was applied, which made it possible to contextualise the terms within the narratives expressed by the interviewees. The qualitative interpretation was supported by direct quotations taken from the text corpus, which allowed each key term to be linked to its specific narrative and semantic function. Here are some relevant examples.

4.1.1 Depopulation and demographic trajectories

The phenomenon of depopulation (spopolamento/calo demografico) in Basilicata is not merely a statistical trend but represents a profound and systemic lived experience for its communities. Interview data elucidate a deeply negative natural balance (births vs. deaths), where deaths significantly outnumber births, compounded by a pronounced exodus of younger generations. As one stakeholder (MB_01) articulated, "*We are los-*

[1] The "€1 houses project" initiative refers to local municipal programs aimed at counteracting depopulation and housing abandonment in inner and marginal areas. Through this scheme, municipalities transfer ownership of abandoned or underused dwellings at a symbolic price, in this case 1 €, while purchasers commit to renovating the properties within a defined timeframe. Beyond the symbolic value of the sale price, the initiative seeks to stimulate local economic activity, attract new residents, and support place-based strategies for rural regeneration.

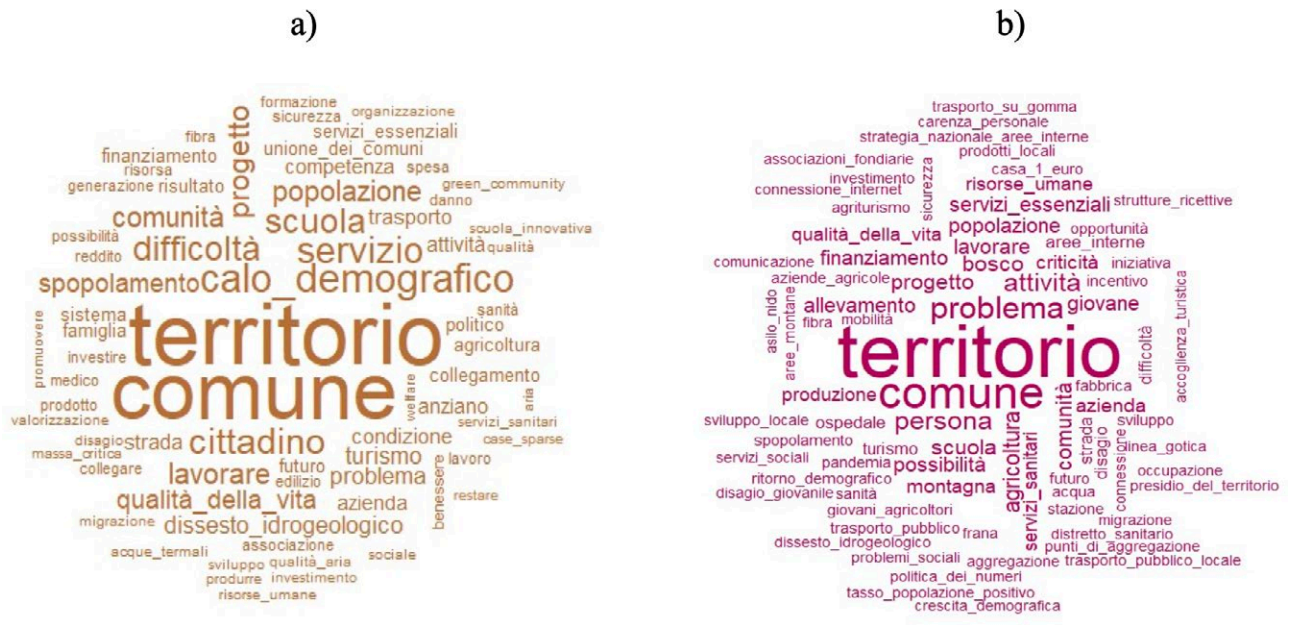

Figure 2. Word clouds generated from textual analysis using the IRaMuTeQ software, based on interviews for the Basilicata region (a) and the Tuscany region (b). The key terms, "territorio" (territory) and "comune" (municipality), highlight the central themes addressed in both corpora. Word size indicates term frequency and correlation.

ing entire generations. They reach the age of 18 and then [...] they leave." This demographic decline is quantified by another participant (MB_03): *"The natural balance (births vs. deaths) is minus 18, minus 19, which means that in five years, almost 100 inhabitants have been lost."* These narratives correspond to the analytical codes of youth exodus, demographic imbalance, and demographic contraction. Conversely, the demographic landscape in Tuscany is characterized by a "positive population trend" (crescita demografica/tasso di popolazione positivo). This growth is propelled primarily by in-migration, including a notable trend of individuals returning to their ancestral or second homes in search of an enhanced quality of life. This is evidenced from MT_02 by observations that *"a demographic return of individuals originally from Vernio is also occurring"* and from MT_01 that *"approximately 10-15 families have returned in recent years; they have purchased detached houses with gardens [...] for a better quality of life compared to the city."* This phenomenon is coded as residential return and attractive in-migration, underscoring the region's appeal.

4.1.2 Essential services and quality of life

While the term "essential services" (servizi essenziali) is pivotal in both regional contexts, its connotations diverge significantly. In Basilicata, the discourse is dominated by themes of scarcity and fragmentation. The administrative structure itself exacerbates these challenges, as one stakeholder explained (MB_2): *"As a highly fragmented municipality, we are compelled to manage multiple instances of every service [...], which results in a duplication or triplication of both problems and costs."* This strain is particularly acute in the educational sector, where dwindling numbers threaten viability MB_4): *"Our school has only 30 children in total. This makes it challenging to sustain the organization of services."* These conditions are analytically captured by the codes inefficient duplication of public services and erosion of the critical mass for educational services. In Tuscany, by contrast, while challenges are acknowledged, the narrative reveals a greater degree of institutional resilience and proactive problem-solving. A key example is the strategic response to healthcare needs (MT_02): *"We decided to establish a Casa della Salute (community health center) [...], which delivers a highquality healthcare service"*. This proactive approach is coded as innovation in territorial healthcare services, highlighting a capacity for adaptive governance.

4.1.3 Work

The term "to work" (*lavorare*) appears in both word clouds but reflects different perspectives in the two

regions. In Basilicata, the term "*lavorare*" is associated with a lack of job opportunities, as expressed by stakeholders who noted the absence of work and the challenges faced by a large segment of the NEET population (Not in Education, Employment, or Training). Expressions like (MB_03): *"[...] work is the big absent and it does not allow us to catch the opportunities of the territory [...], [...] there is a very large segment of NEET population, they have difficulties to find their own work dimension [...]"*, highlight this aspect. These expressions align with the codes of structural unemployment and skills mismatch. On the other hand, in Tuscany, the same term conveys a positive outlook, reflecting the availability of jobs, particularly in small- and medium-sized industries (MT_O1):*"[...] thank goodness Mugello is still today an area where there are industries and therefore job opportunities, whether they are small or medium industries... so there is a job opportunity [...]"*. Furthermore, there are clear signs of innovation and entrepreneurial spirit, particularly in the agricultural sector (MT_03): *"Young farmers are taking marketing very seriously"*. These dynamics are coded as youth entrepreneurship and agricultural innovation.

4.1.4 Tourism development strategies

Similarly, the concept of "tourism" (turismo), present in both analyses, is imbued with distinct strategic orientations in each region. In Basilicata, tourism development is increasingly linked to territorial branding and specialized niches, such as wellness. This is exemplified by the initiative to create *"a territorial brand called Latronico, city of wellness"* (MB_01), which is coded as experiential tourism linked to wellness and health. In Tuscany, the tourism strategy is deeply integrated with the enhancement of existing cultural and landscape heritage. The focus is on sustainable and networked models, as illustrated by the success of a specific trekking route (MT_04): *"The trekking route running parallel to the Via degli Dei (Path of the Gods) [...] generates 1,500 overnight stays for our local accommodation facilities"*. This approach is classified as slow tourism, integrated with the territorial network.

4.1.5 Environmental management and risk perception

Finally, the issue of "hydrogeological instability" (dissesto idrogeologico), while a shared concern, elicits divergent responses and narratives. In Basilicata, it is framed as an immediate and recurrent threat that defines the territory's vulnerability. As one interviewee stated (MB_01), "*Hydrogeological instability is the biggest issue [...]. Flooding, landslides, and canals that need to be fixed"*. This perception corresponds to the codes of structural fragility and natural risk. In Tuscany, while the presence of the same risk is acknowledged, the narrative is oriented towards prevention and active management. The problem is viewed as manageable through proper stewardship of natural resources, reflecting a proactive rather than reactive stance (MT_05): *"If a forest is cared for, it is cut down, water drainage channels are built, the forest is a resource and does not cause problems"*. This perspective is coded as sustainable management of forest resources.

4.2 Similarity analysis

A similarity analysis was conducted using graph theory concepts to gain deeper insights into these dynamics. This method identifies co-occurrences within the text corpus, grouping closely related words into clusters. Each cluster represents a "lexical community" that reflects central themes in the representations of the participants (Salviati, 2017; Reinert, 1983). The more closely and/or overlapping the blocks, the greater their commonality. In this way, words with a high level of co-occurrence with each other will be found in the same communality, instead weakly connected with other communalities (Salviati, 2017). In Basilicata, the analysis revealed four main clusters (Figure 3): territory (*territorio*), municipality (*comune*), service (*servizio*), and demographic decline (*calo demografico*). The central cluster, *"territorio"*, included words such as citizen, essential services, agriculture, difficulty, and development. It is semantically dense and interconnected, highlighting how the territory is not perceived solely as a geographical space, but as a container of needs, challenges and potential. On the one hand, structural weaknesses linked to accessibility and geographical marginality; on the other, the presence of local resources, such as agriculture, which represent opportunities for revitalisation. Furthermore, showed a strong correlation with the cluster *"comune"*, which featured terms such as hydrogeological instability, safety, health services, migration, inhabitants, and funding.

The cluster "*comune*" focuses on institutional and managerial aspects. It is closely related to the themes of safety and environmental security, suggesting that municipalities are perceived as responsible for caring for the territory. The intersection between the two clusters reflects a structural relationship: the municipality is the institutional point of contact between citizens and the territory.

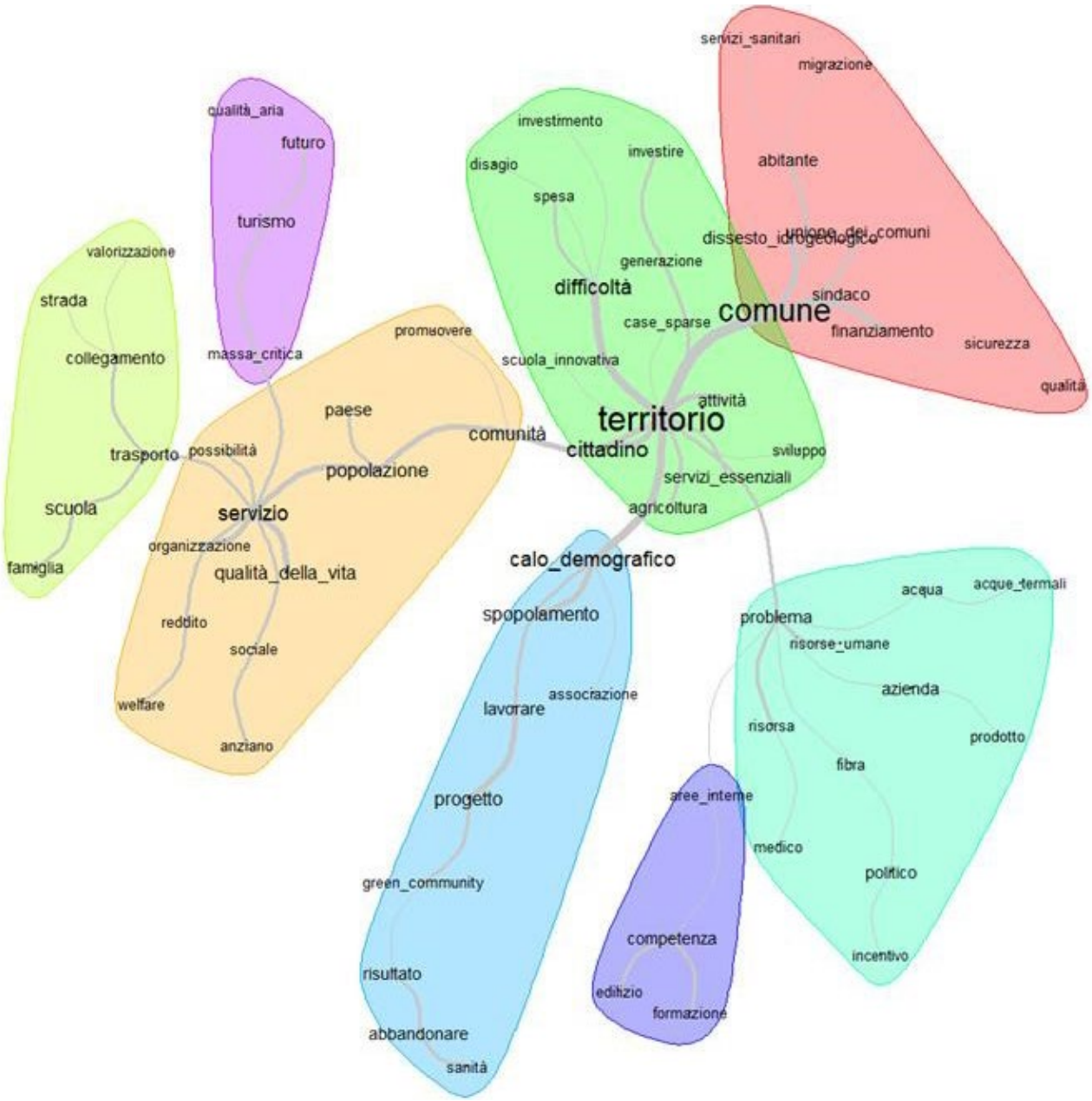

Figure 3. Similarity Analysis generated with the IRaMuTeQ software for Basilicata region. The map shows 4 main thematic clusters based on co-occurrences of terms: (1) territorio (land: green cluster), (2) comune (municipality: red cluster), (3) servizio (service: yellow cluster), (4) calo demografico (demographic decline: light blue cluster).

The cluster *"servizio"*, represents one of the central thematic areas in the text corpus analysed for Basilicata region. This semantic group has developed around a set of terms that denote a strong focus on social, infrastructural and quality of life needs in rural contexts. The most frequent and highly interconnected words include: income, welfare, social services, population ageing, quality of life, transport, school, roads, tourism, air quality, and future opportunities. Within this cluster, two main sub-themes emerge, which can be interpreted as functional sub-clusters. Sub-cluster 1: *Basic Services and Mobility*. This includes terms such as transport, school, and roads, which are linked to the daily accessibility and usability of the territory. These aspects are frequently associated with the logistical difficulties of inland areas, particularly for the elderly and students.

Their presence in the discourse suggests a lived experience of isolation, which is attributed to a lack of fundamental public services. Sub-cluster 2: *Services for Development and Sustainability*. Featuring words like tourism, air quality, and future opportunities, a more proactive and forward-looking narrative emerges, oriented towards leveraging the territory as a resource for sustainable development. The cluster "*servizio*" was also correlated with the cluster *"territorio"*, a connection evidenced by their proximity and partial overlap on the cluster map. This suggests that services are intrinsically linked to the quality and sustainability of the territory. Furthermore, the semantic relationship with the "*calo demografico*" cluster is indirect but significant: the lack or inadequacy of services appears to be a structural cause of depopulation, while simultaneously representing a potential lever to reverse this trend if strengthened through targeted public investment. In summary, the "*servizio*" cluster reflects a set of concrete and perceived challenges in the daily lives of the inhabitants of Basilicata's inland areas. At the same time, it reveals a forward-looking perspective aimed at reconstructing a fabric of services capable of attracting and retaining the population, particularly its youth. This makes the cluster particularly rich and strategically significant for future territorial planning. The cluster *"calo demografico"*, related to the cluster *"territorio"*, grouped terms such as depopulation, desertion, work, project, and green community. This cluster underscores the pressing issue of demographic decline in Basilicata and the importance of developing projects, such as green community initiatives, to combat this challenge and foster regional resilience. The overlap with "*territorio*" underlines the interconnection between demographic dynamics and the quality of the living environment.

In Tuscany, the similarity analysis identified five main clusters (Figure 4): territory (*territorio*), service (*servizio*), zone (*area*), issue (*problema*), and municipality (*comune*). The central cluster *"territorio"* represents a detailed and integrated vision of the regional context, where elements of identity, economic development, environmental sustainability and repopulation of inland areas converge. It includes words like security, tourism, farms, livestock, agriculture, young population, hydrogeological instability, demographic return, and production, and exhibited strong correlations with its sub-clusters. These latter express an integrated representation of 'living' the territory. Two sub-clusters emerge within this cluster. Sub-cluster 1: *Territory as a Productive and Scenic Resource*. Terms such as agriculture, livestock farming, tourism, local products, and agricultural enterprises delineate a vision of the territory as a driver of local development. Agritourism practices and the valorisation of traditional local products are perceived not only as economic activities but also as instruments for cultural and environmental promotion. Sub-cluster 2: *Territory as a Space for Return and Regeneration*. Featuring words such as youth, demographic return, €1 houses project, mountain, and opportunities, a proactive narrative emerges in which the territory is viewed as an opportunity for repopulation and social innovation, particularly by young people and new inhabitants. There are also references to structural challenges, such as hydrogeological instability, which frequently appear alongside words like safety and prevention, signalling the need for investment in environmental risk management. However, this problematic component is integrated into a resilient and proactive vision of the territory. The "*territorio*" cluster in Tuscany should therefore be interpreted in a dual sense: on the one hand, it summarises a set of concrete needs related to the stewardship and valorisation of the land; on the other, it fosters a strategic vision in which the rural landscape becomes a space for innovation, inclusion, and rebirth.

The clusters *"servizio"* and *"area"* were also closely linked, grouping terms such as meeting points, essential services, health services, local development, public transport, forest as a resource, youth challenges, internet connectivity, and depopulation. These clusters highlighted both the critical services needed to improve QoL and the challenges faced by the region. Furthermore, shows strong interconnections with the "*territorio*" cluster. The latter shares spatial and infrastructural references (public transport, forest as a resource, local development) with the "*area*" cluster. On the other hand, it shares the concepts of essential services and quality of life with the "*servizio*" cluster, reinforcing the centrality of the territory in the design of local public policies. Lastly, the clusters *"problema"* and *"comune"*, that showed weaker correlations with the cluster *"territorio"*. This apparent dispersion may be due to the stakeholders' use of synonymous terms, such as criticality and issue, or administered land and municipality. Despite this, these clusters still encompassed significant terms, including human resources, communication, future immigration, population growth, social services, financing, and income. Although less central, the "*problema*" and "*comune*" clusters function as contextual indicators.

The "*problema*" cluster signals the grey areas of the discourse: elements of discontinuity, inequality, or uncertainty for which participants struggle to find a shared vocabulary. The "*comune*" cluster shows that the local level is acknowledged as crucial, yet also as vulnerable and in need of support, both in terms of governance and

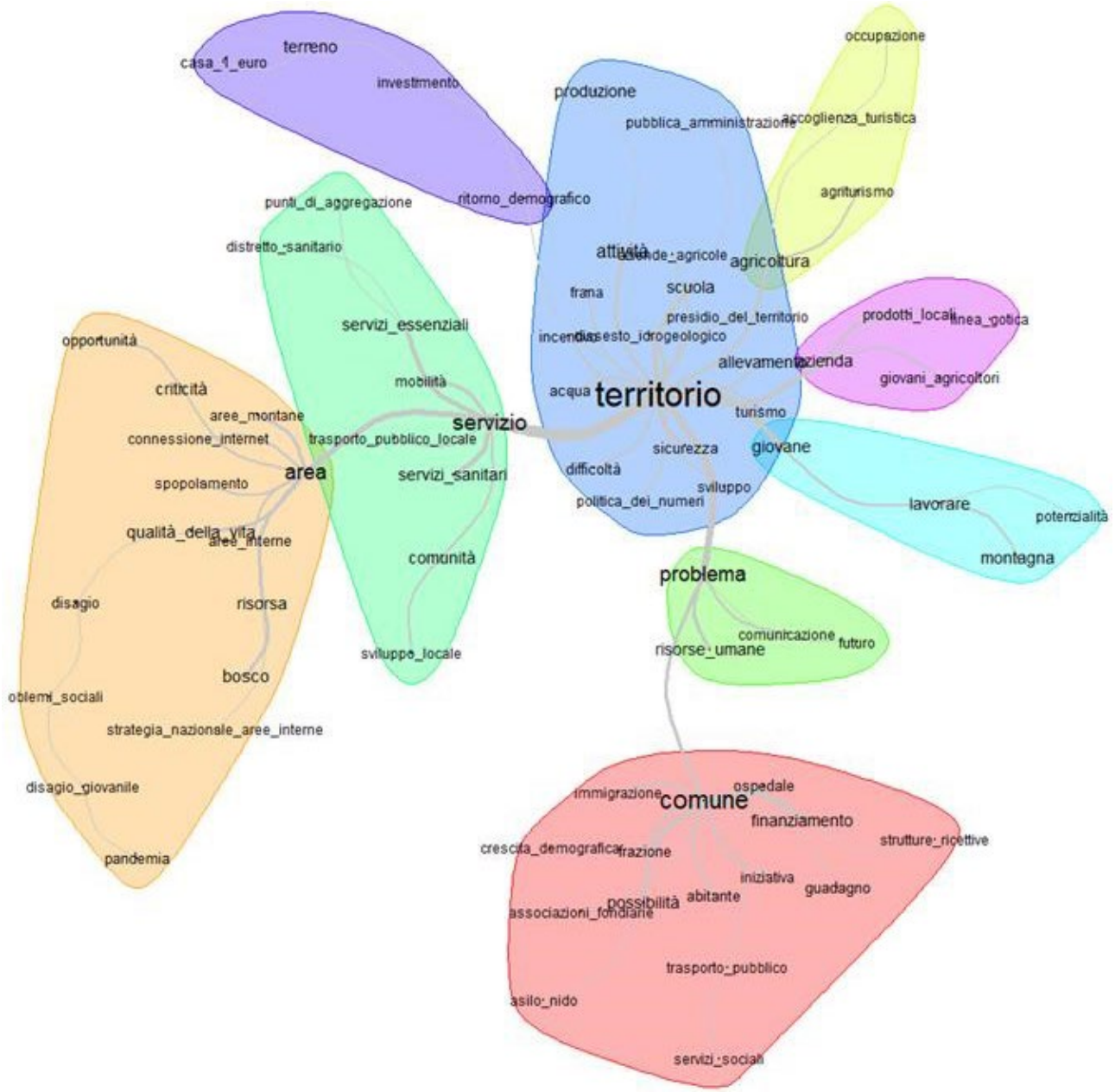

Figure 4. Similarity Analysis generated with the IRaMuTeQ software for Tuscany region. The map shows 5 main thematic clusters based on co-occurrences of terms: (1) territorio (territory: blue cluster), (2) servizio (service: green cluster), (3) area (zone: orange cluster), (4) problema (issue: light green cluster), and (5) comune (municipality: red cluster).

resources. In summary, their marginality on the map does not correspond to a lack of thematic relevance but rather to the lexical dispersion and variability with which these institutional and problematic issues are addressed.

The following Table 3 provides a comparative overview of the key themes emerging from the word cloud and similarity analysis conducted on the interview corpora of Basilicata and Tuscany.

4.3 Descending Hierarchical Classification (DHC) and Confirmatory Factor Analysis (CFA)

A thematic exploration was conducted using the Descending Hierarchical Classification (DHC) technique to deepen the analysis, applying the Reinert method (1983). This approach facilitates the identification of clusters composed of words with shared characteristics

Table 3. Comparative overview word cloud and similarity analysis.

Category	Basilicata	Tuscany
Key Themes	Depopulation, hydrogeological instability, scattered houses, union of municipalities	Population growth, forests, public transport, €1 house project
Clusters	Territory, municipality, essential services, agriculture, demographic decline	Territory, area, services, issue, municipality
Narrative	Systemic crisis, isolation, service shortages	Territorial regeneration, return to rural areas, residential attractiveness
Structure	Clusters centered on fragility and vulnerability	Clusters focused on territorial enhancement

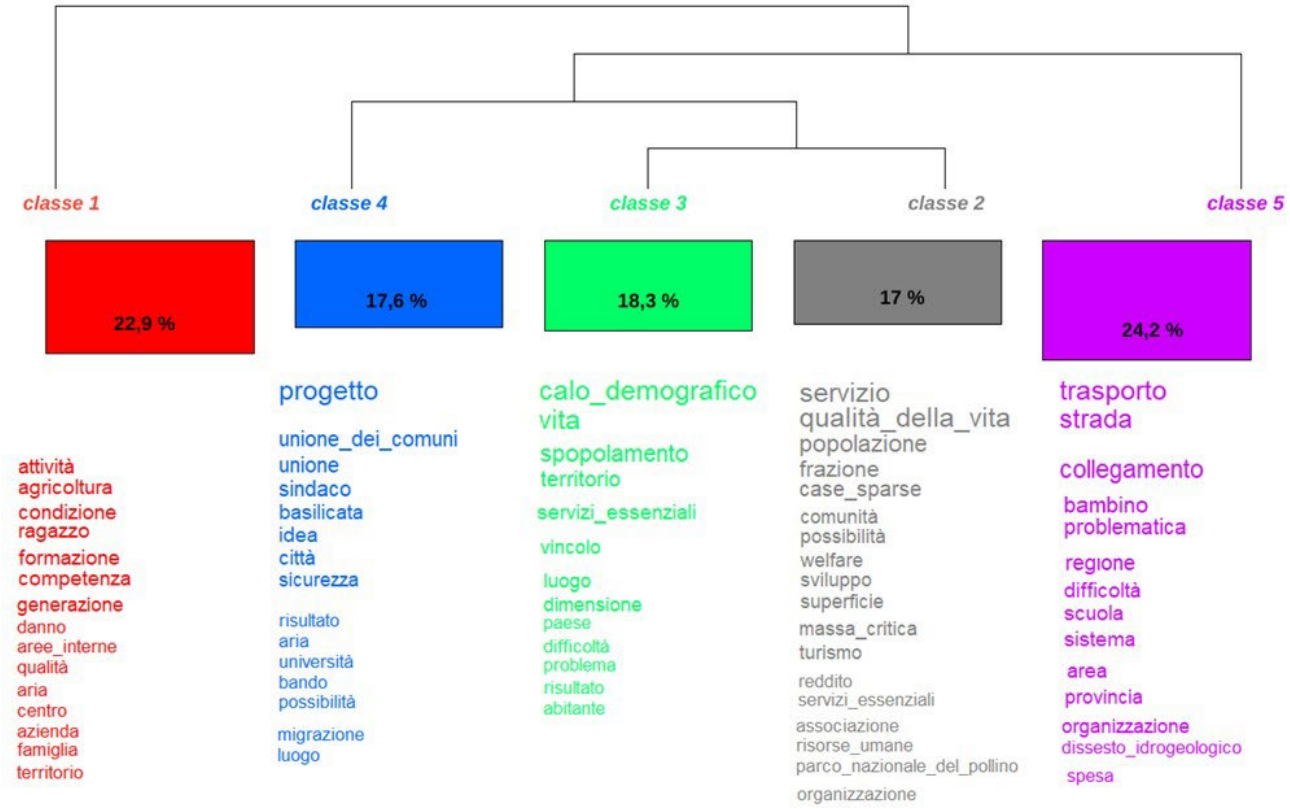

Figure 5. Descending Hierarchical Classification (DHC) of themes derived from the textual analysis of interviews related to the Basilicata region, generated using the IRaMuTeQ software. The five identified classes (red: Cluster 1, blue: Cluster 4, green: Cluster 3, grey: Cluster 2, and purple: Cluster 5) group semantically related terms, highlighting the main topics discussed. The percentages indicate the distribution of terms across the different classes.

represented through a dendrogram of classes (Souza et al., 2018). The DHC technique statistically identifies homogeneous groups of topics within a text corpus by analysing the frequency of words. The ChiSquare (χ^2) test is employed to measure the associative strength between words and their respective classes, with a value greater than 3.84 indicating significance at $p<0.0001$ (Lahlou, 2012).

In Basilicata, five distinct classes emerged from the analysis (Figure 5).

Class 5 (24.2%) is the most prominent, highlighting mobility issues, such as inadequate public transport and connections, damaged or impassable roads due to hydrogeological instability, and poor land management. This category reflects the physical and infrastructural crisis facing the region. For many public officials, mobility is not merely a logistical problem but a community-wide issue: such deficiencies lead to a scarcity of services and exacerbate depopulation. The difficulty in moving around restricts access to healthcare, education, employ-

ment, and culture, creating a vicious cycle of isolation and marginalization*: "Our small municipality remains isolated for three months of the year due to landslides. For this reason, we have implemented a social taxi service for the elderly and students".*

Class 1 (22.9%) emphasizes the relationship between agricultural land, production quality, and the shortage of young or adequately trained farmers. This class indicates a strong productive identity and reveals that while agricultural management is a valuable asset, it requires policies for generational renewal, support for innovation, and access to land. Without targeted action to attract young farmers, the rural fabric of the Basilicata region risks a progressive decline, regardless of the quality of its products. Class 3 (18.3%) addresses the intertwined issues of depopulation, demographic decline, and essential services. This represents one of the main problems afflicting Basilicata's inner areas, where the lack of essential services contributes to depopulation and demographic decline. At the same time, the reduced population discourages the provision of such services, creating a negative vicious circle. Class 4 (17.6%) is the class of local strategies for development and resilience. This class represents communities that, despite structural constraints, demonstrate a distinct capacity for endogenous project development. Through resilient and community-based initiatives – often rooted in the cultural, tourism, or social sectors – these areas position themselves not as passive policy recipients, but as proactive agents experimenting with innovative solutions for local development. Finally, class 2 (17%) is the class of local governance, planning, and networks. Complementing the previous cluster, this group represents its political-institutional counterpart. Here, local governance, though operating with limited resources, is characterized by the adoption of innovative and integrated strategic planning. This includes initiatives such as smart welfare, the promotion of short supply chains, and administrative cooperation.

Confirmatory factor analysis (CFA) further supports these findings, with two principal factors that collectively explain 56.44% of the total variance. The first factor, accounting for 28.9% of the variance, is defined as the *Axis of ProjectBased Resilience*. The second factor (27.54%) represents the *Axis of Structural Criticality*. Together, these axes constitute two latent dimensions that semantically organize the discourse of local actors and are visualized on the X and Y axes in Figure 6.

The analysis shows that classes 2, 3, and 4 are closely interconnected and situated in the same quadrant. This indicates the necessity of addressing major issues (class 3) by implementing targeted socio-economic initiatives (classes 2 and 4). This suggests that local communities are not passive in the face of the crisis, but develop detailed and proactive responses, even in a context of scarcity. Conversely, classes 1 and 5 are situated in separate quadrants, reflecting their relative independence and lack of a direct cause-and-effect relationship. While these classes address important themes highlighted by stakeholders, they are not perceived as directly influencing one another. The areas covered in the interviewees' texts remain more descriptive than strategic. In summary, the CFA in Basilicata region confirms the centrality of the crisisresponse dynamic, highlights critical "shadow areas", and underscores the coherence between perception and narrative. In Tuscany (Figure 7), the most significant class, class 2 (24.3%), encapsulates critical challenges in the region's inner areas, such as limited access to primary schools, inadequate essential services, crime, and shortages of human resources and healthcare. The analysis of Tuscany's inland areas reveals a condition of systemic vulnerability. The level of vulnerability appears comparable to that observed in the Basilicata region, although the Tuscan situation exhibits distinct regional characteristics: a less pronounced degree of geographical isolation is offset by a marked crisis in essential services, which ensure the connection between local communities and the region's main urban centres.

Closely related to class 2 is class 3 (18.4%), which outlines strategies for socio-economic improvement, including leveraging forests as a resource, boosting tourism, creating jobs, improving mobility, and enhancing local governance. Moreover, this class represents the regional strategy aimed at redefining territorial identity. Moving beyond the mere acknowledgment of the service deficit, it promotes a revival founded upon culture and tourism. Class 1 (20.3%) focuses on Tuscany's agricultural sector, characterized by young farmers, high-quality local products, livestock, food processing, and the growth of agritourism. In contrast to Basilicata, the agricultural sector in Tuscany shows a superior degree of integration within local development strategies. This integration is bolstered by greater youth participation and an enhanced capacity to articulate a contemporary agro-territorial vision. Class 5 (13%) highlights tools for development and repopulation, such as economic incentives, university collaborations, and the "1€ home project", trying to convert territories into opportunities for new inhabitants. Lastly, class 4 (24%), while representing a significant portion of the text, appears as an outlier, addressing a political vision for the future through elements such as programming, policy frameworks, and public initiatives. The class can be defined as politically aspirational because it expresses a long-term strategic vision that transcends the management of immediate

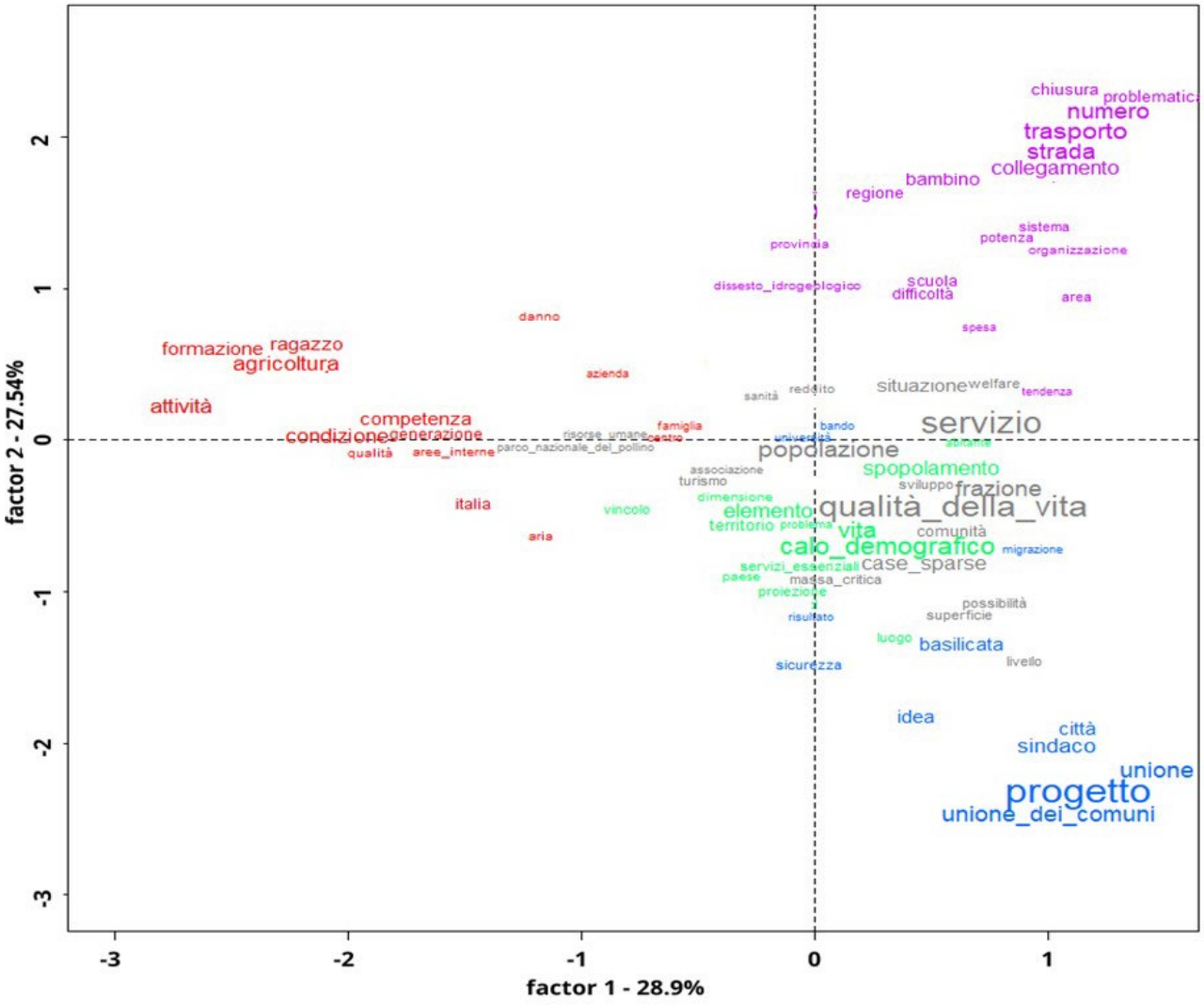

Figure 6. Confirmatory Factor Analysis (CFA) of themes derived from the textual analysis of interviews related to the Basilicata region, generated using IRaMuTeQ software. The CFA reduces data dimensionality by grouping terms into two main factors (X-axis and Y-axis). The colour of the words corresponds to the clusters identified in Figure 5, highlighting the semantic associations between terms.

crises. It outlines a transformative orientation aimed at reforming the structural conditions of the inland areas.

The confirmatory factor analysis (CFA) for Tuscany yielded two factors that collectively account for 55.31% of the total variance (see Figure 8). These have been identified as factor 1 *Axis of Structural Vulnerabilities* (explaining 29.67% of the variance) and factor 2 *Axis of Strategic Response and Political Vision* (explaining 25.64% of the variance). CFA revealed strong connections between classes 2 and 3, which are located in the same quadrant. This underscores the interplay between the primary challenges in Tuscany's inner areas (class 2) and the proposed solutions for socio-economic development (class 3), aligning with the DHC results. In contrast, classes 1, 4, and 5 exhibit greater dispersion and independence. These classes are less directly linked to the narrative of daily emergencies and instead fulfil complementary and strategic roles. They are configured as project-based and political-institutional domains, to be activated in parallel with addressing immediate needs. Their semantic distance from classes 2 and 3 signals that they are not yet fully integrated into the operational management of crises, but represent potential levers for structural change. Indicating that while important to stakeholders, they do not form a cohesive cause-and-effect relationship with other clusters. In summary, the CFA for Tuscany highlights a convergence between local needs and responses, the presence of governance

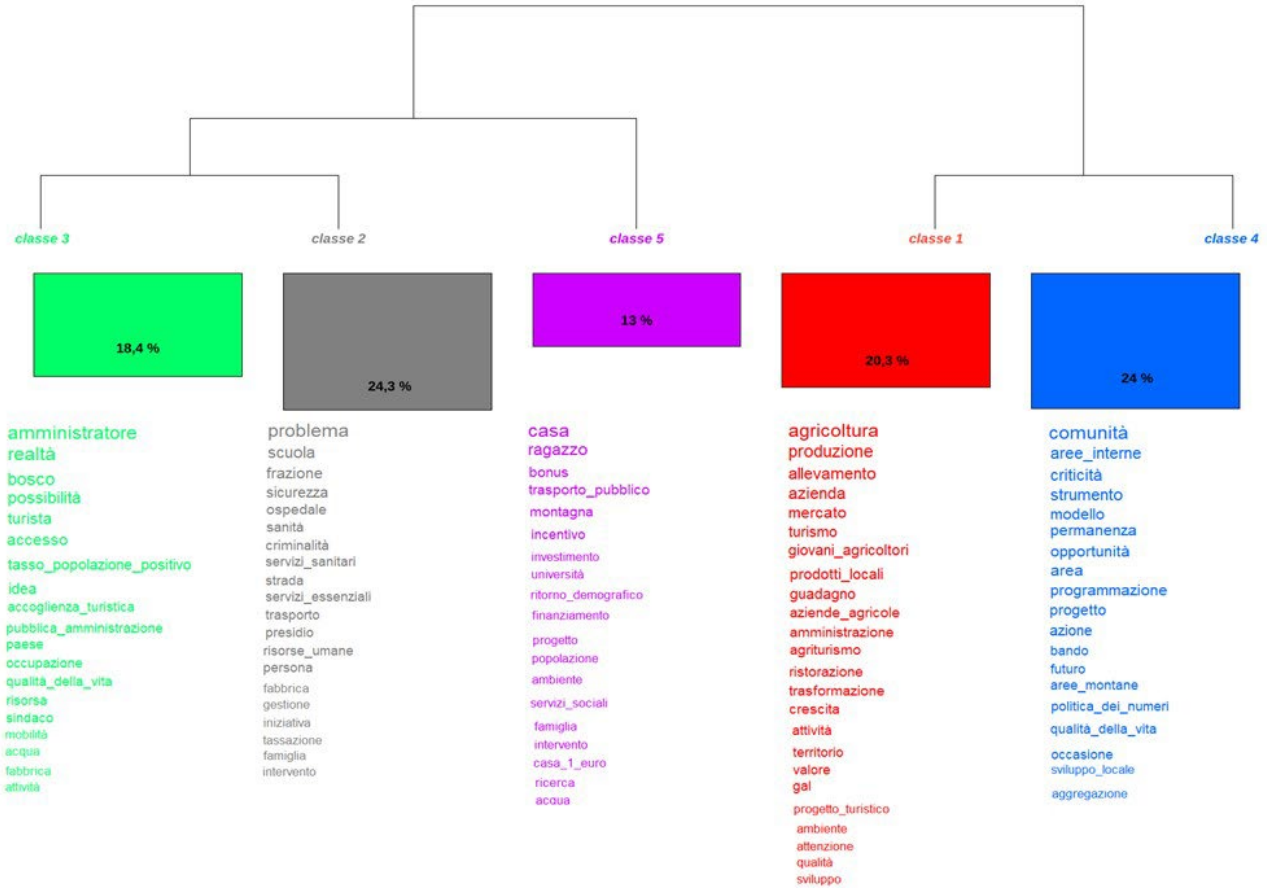

Figure 7. Hierarchical Descending Classification (DHC) of themes emerging from the textual analysis of the interviews related to Tuscany, generated using the IRaMuTeQ software. The five identified classes (green: cluster 3, grey: cluster 2, purple: cluster 5, red: cluster 1, and blue: cluster 4) group semantically related terms, highlighting the main topics discussed. The percentages indicate the distribution of terms across the different classes. The factors account for 28.9% and 22.54% of the total variance, respectively.

tools and strategic visions that remain insufficiently integrated, and a conscious yet segmented representation of territorial challenges.

The following Table 4 presents an integrated comparison between the two regions analyzed (Basilicata and Tuscany), based on the results of the DHC and CFA. It summarizes the main thematic classes identified, the latent factors extracted, and the discursive and analytical implications that characterize each territorial context.

4.4 Integrated summary of results

The qualitative analysis revealed a nuanced framework of local administrators' perceptions regarding the primary factors influencing quality of life in inland areas, highlighting specific convergences and divergences between Basilicata and Tuscany. In both contexts, the themes of territory, essential services, agriculture, and environmental risk are central, although framed by distinct rationales and priorities. In Basilicata, narratives of structural vulnerability, depopulation, isolation, and service deficiencies are predominant; these, however, are accompanied by experiences of territorial resilience based on endogenous initiatives. Tuscany, in contrast, demonstrates a stronger integration of local governance, development strategies, and projects aimed at territorial regeneration and attracting new residents. The analysis led to the identification of two principal interpretative axes: the 'Axis of Structural Vulnerability', which underscores the systemic fragilities of the territories; and the 'Axis of Strategic Response', which reflects the capacity for political, administrative, and project-based mobilization. These axes translate into a series of challenges and opportunities, summarized in the following table (Table 5), which constitutes a valuable knowledge base for the formulation of targeted policies for the sustainable development of inland areas.

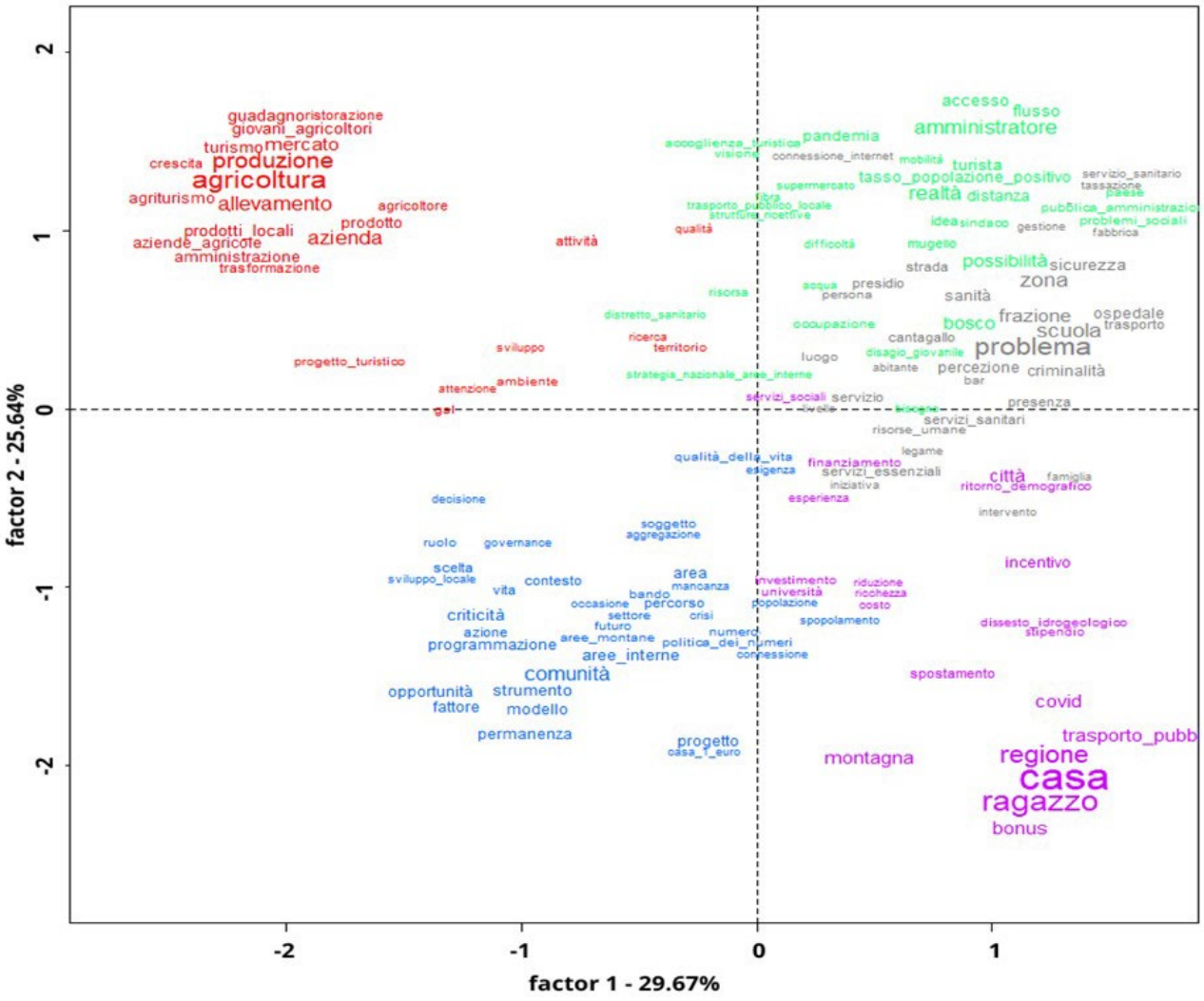

Figure 8. Confirmatory Factor Analysis (CFA) of themes emerging from the textual analysis of the interviews related to Tuscany, generated using the IRaMuTeQ software. The CFA reduces data dimensionality by grouping terms into two main factors (X-axis and Y-axis). The word colours correspond to the clusters identified in Figure 7, highlighting the semantic associations between terms. The factors explain 28.67% and 25.64% of the total variance, respectively.

Table 4. Integrated comparison between DHC and CFA.

Class / Factor	Basilicata	Tuscany
Class 1 (DHC)	Agriculture and lack of generational turnover	Integrated agriculture and local products
Class 2 (DHC)	Local governance and planning	Deficiencies in essential services
Class 3 (DHC)	Depopulation and essential services	Economic and territorial development strategies
Class 4 (DHC)	Resilient local projects and community initiatives	Political vision and long-term programming
Class 5 (DHC)	Infrastructure and mobility issues	Repopulation tools and €1 house project
Factor 1 (CFA)	Axis of Project-Based Resilience	Axis of Structural Vulnerability
Factor 2 (CFA)	Axis of Structural Criticality	Axis of Strategic Vision and Political Response
Association	Strong connections between local issues and responses, though thematically fragmented	Greater coherence between needs and strategies, though vision is not fully operationalized
Implications	Focus on urgency and local solutions; discourse remains partially segmented	Strategic discourse more cohesive and development-oriented

Table 5. Challenges and Opportunities.

Thematic Category	Identified Challenges	Opportunities
Demography	Depopulation, negative natural balance, youth outmigration (especially in Basilicata)	Residential return and new migration (e.g., €1 house project in Tuscany)
Essential Services	School and healthcare deficiencies, administrative fragmentation, limited mobility	Creation of health centers, smart welfare initiatives, alternative transport solutions
Work and Human Resources	Youth unemployment, skills mismatch, lack of qualified human resources	Youth entrepreneurship and innovation in agriculture (especially in Tuscany)
Tourism and Local Development	Limited tourism attractiveness or fragmented offer	Development of territorial brands (e.g., 'City of wellness'), sustainable trekking, slow tourism
Environment and Risk	Recurrent hydrogeological instability, poor land maintenance	Sustainable forest management, proactive prevention, promotion of natural resources
Governance and Vision	Coordination difficulties among local authorities, scarce resources	Participatory strategic planning, Union of Municipalities, access to NRRP funds

5. DISCUSSION

The results presented through word cloud, similarity analysis, and hierarchical classification provide critical insights into how local stakeholders perceive QoL in marginal rural areas. In both Basilicata and Tuscany, stakeholders strongly emphasized the importance of essential services – particularly healthcare, education, and transport – as core components of rural well-being. As shown in the similarity analysis (Figures 3 and 4), the clusters labelled "servizio" and "territorio" were central in both regions. This supports Moseley and Owen's (2008) argument that service accessibility lies at the heart of rural vitality. However, the perception of these services varied significantly. In Basilicata, the cluster "calo demografico" (Figure 3) reveals that service scarcity is intertwined with demographic decline and infrastructural limitations. Stakeholders described a cycle of depopulation and service withdrawal, where insufficient transport and healthcare access contribute to population loss, which in turn justifies further service cuts. This aligns with the DHC Class 3 (Figure 5), highlighting a perceived need for urgent interventions to break this cycle. Indeed, Basilicata communities faced the so-called "rural vulnerability cycles" (Marsden, 2009) where demographic, economic, and service declines reinforce each other. This perception of demographic decline as a pressing issue reflects local experiences of ageing populations, out-migration, and the subsequent loss of human capital, all contributing to the region's economic stagnation. Local stakeholders are attuned to the daily consequences of these demographic shifts, such as the closure of schools, reduced services, and weakened social networks (Black et al., 2019).

Conversely, in Tuscany, although stakeholders also pointed to service needs (DHC Class 2, Figure 7), the overall perception was more optimistic. The presence of ongoing projects, such as the "1€ house" initiative and forest-based tourism (DHC Class 5 and 3), points to a more proactive local governance model. The cluster "giovani_agricoltori" and associated terms suggest that youth engagement and agricultural diversification are seen as realistic strategies for repopulation and rural vitality, supporting Brunori and Rossi's (2007) work on rural diversification.

Another relevant dimension concerns perceptions of agriculture. In Basilicata, Class 1 of the DHC and the associated CFA quadrant (Figure 6) link agriculture to structural challenges, particularly the lack of generational turnover and the environmental fragility of rural land. Stakeholders explicitly mentioned the absence of young and adequately trained farmers as a threat to agricultural sustainability. This reflects findings by Li et al. (2019) and Marsden (2009) on the compounding effects of rural demographic and economic decline. In Tuscany, by contrast, Class 1 (Figure 7) connects agriculture to local identity and economic opportunity, emphasizing value-added products and integration with tourism. This perception aligns with Woods' (2005) view that rural areas can leverage local assets to create new development pathways.

Importantly, the role of local governance was repeatedly emphasized. In Basilicata, stakeholders pointed to institutional weaknesses and limited capacity to coordinate development projects, as reflected in DHC Classes 2 and 4. In Tuscany, the proximity to regional institutions and stronger collaboration among municipalities facilitated more strategic planning and access to funding (see Figure 8). This resonates with the place-based approach advocated by Barca et al. (2014).

Overall, these findings support the view that rural development trajectories are deeply mediated by local

perceptions and governance capacity. Rather than presenting universal challenges, our results demonstrate that the same issue – be it demographic change, agriculture, or service access – is understood and acted upon differently depending on context. Our results suggest the need for policy approaches that account for local perceptions and capacities, supporting Marsden's (2016) and Pugh and Dubois' (2021) call for context-sensitive rural development strategies. This is particularly important given the emerging challenges highlighted by stakeholders.

The contrasts between Basilicata and Tuscany demonstrate that rural development trajectories are not predetermined but shaped by the interactions between perceptions, institutional capacity, and resource availability. This supports the work by Li et al. (2019) on the diversity of rural evolution pathways while providing specific insights into how local context mediates development outcomes.

Finally, our findings point out important insights about rural governance and policy implementation. Indeed, stakeholder perceptions significantly influence how policies are interpreted and implemented locally (Lopolito et al., 2015; Scott, 2012). This is particularly evident in how similar EU rural development initiatives yield different outcomes in Basilicata versus Tuscany, supporting the place-based development approaches (Barca et al. 2014).

6. CONCLUSIONS

This study set out to investigate how local stakeholders in inner areas of two Italian regions, Basilicata and Tuscan, perceive QoL and to identify the socio-territorial dynamics that shape rural development. The perspectives of stakeholders, grounded in local knowledge and lived experiences, offer invaluable insights for informing policies and initiatives aimed at enhancing QoL and fostering community revitalization in rural areas. Through a qualitative analysis of semi-structured interviews, supported by textual processing, we addressed three core research questions.

First, regarding the dimensions of well-being perceived as most relevant, stakeholders in both regions emphasized access to essential services (health, education, transport), economic opportunities, and demographic stability. However, the interpretation of these dimensions varied contextually: in Basilicata, stakeholders framed them as areas of structural deficiency, while in Tuscany they were linked to opportunities for innovation and revitalization.

Second, the analysis revealed region-specific challenges and opportunities. In Basilicata, depopulation, service erosion, and institutional fragility emerged as interrelated issues. Tuscany stakeholders, on the other hand, identified demographic return, youth entrepreneurship, and multifunctional agriculture as promising development vectors. These divergent framings demonstrate how similar problems, such as outmigration or infrastructure needs, are differently conceptualized and addressed, confirming the relevance of context-sensitive analysis (Pugh and Dubois, 2021).

Third, our results illustrated the interaction among demographic dynamics, service provision, and territorial governance. The co-occurrence patterns and hierarchical classes pointed to cyclical processes in Basilicata – where service deficits contribute to population decline – and to more resilient configurations in Tuscany, where place-based initiatives are helping to stabilize or reverse rural decline.

From a theoretical perspective, this study contributes to debates on rural well-being by demonstrating the central role of perception in shaping development priorities. Our findings support capability-based (Sen, 1999; Nussbaum, 2000) and governance-oriented approaches, highlighting the need to include stakeholder perspectives in assessments of rural vitality. Methodologically, the integration of textual analysis with qualitative coding reinforces the value of combining Grounded Theory (Glaser and Strauss, 1967) and computational tools (Ratinaud, 2008; Camargo and Justo, 2013) in rural studies.

The policy implications are equally significant. The evidence suggests that a one-size-fits-all strategy is inadequate for rural development. In Basilicata, investment should prioritize rebuilding institutional capacity and infrastructure, while in Tuscany, policy can focus on consolidating existing diversification pathways. In both cases, policies must respond to local framings and lived experiences, not just statistical indicators (Scott, 2012).

Despite the contributions provided, this study has limitations that should be acknowledged. The focus on mayors, although justified by their institutional role and their privileged position in observing territorial dynamics, excludes other relevant stakeholder groups whose perspectives could further enrich the understanding of well-being in inner areas. Moreover, the analysis is limited to two Italian regions, Basilicata and Tuscany, characterized by specific socio-territorial configurations; therefore, the results reflect strongly contextualized dynamics and cannot be automatically extended to other rural contexts.

Future research should involve a larger and statistically representative sample, including broader stakeholder categories, such as youth, women, and sectoral representatives, to deepen the understanding of intra-regional diversity. Expanding the analysis to other regions could

also enhance generalizability and contribute to comparative theorization across European rural contexts.

In conclusion, this study reinforces the importance of perception-led, place-based strategies in addressing rural marginality. By foregrounding the voices of local administrators, it offers actionable insights for designing policies that are both territorially embedded and socially responsive.

FUNDING DECLARATION

This study was carried out within the Agritech National Research Center and was funded by the European Union – NextGenerationEU under the Italian National Recovery and Resilience Plan (PNRR), Mission 4, Component 2, Investment 1.4 (Directorial Decree No. 1032 of 17/06/2022; Project code CN00000022). The views and opinions expressed in this manuscript are solely those of the authors and do not necessarily reflect those of the European Union or the European Commission, which cannot be held responsible for them.

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APPENDIX

1. I would like to begin by asking for a brief, general description of the territory you administer. Could you please specify its name, geographical location, and province? I am also interested in knowing if it is part of a national park or nature reserve and, if so, what specific constraints or regulations apply. Finally, could you provide the approximate population?
2. Regarding local services, I would like to inquire about their importance, presence, and the community's level of satisfaction with them. Specifically, I am interested in:
    i. Education.
    ii. Healthcare services, including hospitals, local health authorities (such as Azienda Sanitaria Locale – ASL), community health centres, social assistance services, and pharmacies.
    iii. Which is the nearest urban centre that offers a comprehensive range of services? I would also like to know the typical distance and travel time to reach it.
    iv. Transportation infrastructure, such as train and bus services, and the condition of the road network.
    v. The role of tourism. Is it a significant sector in the area? If so, what is the availability of accommodation and dining facilities? vi. The presence of commercial services and amenities, such as supermarkets, postal services, banks, tobacconists, and clothing retail.
    vii. Recreational, sporting, and cultural facilities, including cinemas and community centres.
3. Could you describe the social fabric of the community? Furthermore, I would like to know if there are significant or established immigrant communities residing in the area.
4. Regarding safety and security, what is the general perception within the community? Are there any specific safety concerns I should be aware of?
5. I would like to inquire about the quality of the local environment and the state of the landscape.
6. From your perspective, what would you identify as the main challenges, resources, and strengths of this territory?
7. Do you observe specific challenges or difficulties faced by particular socioeconomic groups, such as young people, women, or immigrants? If such challenges exist, I would like to know if any specific policies or interventions have been implemented to support these groups and, if so, what they entail.
8. In relation to the municipal administration, I would like to ask if you consider the available human resources to be sufficient. Furthermore, are they adequately trained to meet the current and future needs of the municipality?
9. Focusing on the agricultural sector, I would like to understand the main difficulties faced by local farming operations. On a related note, I am interested to know if there is a presence of young farmers or entrepreneurs who have chosen to remain in and invest in the local agricultural economy.
10. I would like to inquire about demographic trends. Have you observed a tendency towards depopulation in your municipality? If so, I am interested in learning about any strategies or specific projects, such as the 'One-EuroHouse' initiative, that have been implemented to counteract this trend.
11. Regarding sustainable development, I would like to know if the municipality has received public funding for related initiatives. If so, do you consider this funding to be sufficient to achieve your objectives?
12. In your opinion, what actions or policies could be suggested to further improve the quality of life in this area?
13. Finally, I would like to explore the perspective of young people. What do you believe are the primary reasons that motivate young people to remain in the municipality? Furthermore, what arguments would you use to persuade young individuals or families to move here?

AESTIMUM
CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Firenze University Press
www.fupress.com/ceset

OPEN ACCESS

Citation: Battisti, F., Campo, O. & Perdonò, M. (2026). Assessing places' liveability: informational entropy for the construction of a set of criteria and indicators. *Aestimum* 88: 29-49. doi: 10.36253/aestim-17653

Received: April 1, 2025

Accepted: May 26, 2025

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Assessing places' liveability: informational entropy for the construction of a set of criteria and indicators

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Abstract. The growing interest in well-being as a quality-of-life paradigm has led to a critical revision of its traditional conception. It is no longer limited to indicators of material prosperity and physical health (objective well-being indicators) but also individual perceptions of quality of life and happiness (subjective well-being indicators). In this new conception, the living environment plays a key role. The definition of well-being indicators based on the perceptual assessments of an urban environment crucially requires interdisciplinary skills. Using an investigative approach based on informational entropy, the objective of this paper is to construct a taxonomy that allows for the assessment of the quality of an environment to achieve adequate well-being standards and thus the improvement of quality of life. In detail, the article explains the methodological process to define a structured set of criteria, sub-criteria, and their associated indicators for evaluating the characteristics of an urban environment and the physical and functional variables that contribute to achieving specific well-being thresholds. Through the involvement of a significant sample of 100 subjects, the results of the work consist of a set of 132 sub-criteria for the assessment of liveability.

Keywords: wellbeing, liveability, informational entropy. .

1. INTRODUCTION

Some epochal changes and events have affected the world in recent years, such as globalization, the technological and digital revolution, increasing urbanization, pandemics, and climate uncertainties. This has led to rethinking the concept of well-being, no longer associated exclusively with indicators of material prosperity and physical health (objective well-being indicators), but rather related to individual perceptions of quality of life and happiness (subjective well-being indicators).

In Europe, over the past ten years and beyond, there has been a growing focus on the so-called "Economy of Wellbeing". In this framework, well-being and quality of life are no longer analyzed and evaluated through tra-

ditional, objective economic indicators, such as gross domestic product (GDP) or the level of infrastructure of an area (services). Instead, holistic, subjective well-being indicators, linked to personal perceptions, aimed at better incorporating the dimensions that influence citizens' quality of life (Varotto, 2019; Battisti, 2023), are adopted. Thus, in the most recent EU guidelines (see Personal and Social Well-Being from European Social Survey (ESS) Round 6) (European Social Survey, 2018), the concept of well-being is now unstructured and multidimensional (Bartolini and Bilancini, 2010); among the components affecting well-being, the community in which one lives, and thus the place, plays a key role. The idea that economic growth was the best way to maximize well-being has now been superseded (Layard, 2005a; Bartolini and Bilancini, 2010; Easterlin, 2013; European Commission, 2018). Instead, it is now recognized that the well-being of individuals is linked to the ability to create, or choose, an environment that allows them to realize their full potential and enjoy their fundamental rights (Āzena and Keiss, 2009; International Labour Organization, 2019; United Nations, 2015; World Bank Group, 2019). Particular emphasis is therefore placed on the liveability of territories.

In the scientific literature, liveability refers to similar concepts with different nuances: it can be defined as "suitability to human life" (Merriam-Webster, 2018), "quality of life, well-being, and happiness" (Veenhoven, 2000), "quality of place and its synonyms" (Burton, 2014). The concept of liveability is thus closely interdependent with that of well-being, being summarized as perceived well-being within a place, dependent on objective factors (characterizing the place) but also subjective factors (related to individuals' perception).

Hence, the relationship between individuals' well-being and place becomes a subject of scientific interest, not least in light of the momentous changes that have had a relevant impact on human life in recent years, among which is the digital revolution that has led to the digital transition, in particular.

The digital transition can be described as an overhaul of administrative, work, business, and even recreational practices, using digital technologies to make them more efficient while achieving easier and more accessible data collection and evaluation. Indeed, in this society undergoing a digital transition, more and more functions and services are being performed through computer networks and computers. This has changed habits, ways of working, and the use of leisure time (OECD, 2019).

The repercussions of the digital transition on the territory have begun to be studied, mainly focusing on the immaterial transfer of services that were historically delivered physically, and the impact of this change on mobility (traffic) and the reuse of buildings that have lost their original use. There are almost no studies on the impacts of the digital transition on residential mobility, well-being, and liveability of places. Online citizen services, e-commerce, social networks, and new modes of social relations, but especially "smart working", can indeed significantly affect the type and quality of people's lives and affect "residential mobility".

Smart working, which potentially affects more than 15 million workers in Italy (employees in the service sector, according to ISTAT data) (ISTAT, 2021), expanded rapidly between 2020 and 2021 due to the COVID-19 pandemic and has demonstrated non-negligible merits, such as reduced management costs for employers, reduced time and costs dedicated to home-to-work commuting, and thus reduced environmental pollution. In some cases, this has even triggered repopulation phenomena in previously underpopulated or abandoned areas (Acampa and Pino, 2024).

This change is epochal, considering that it is taking place for the first time in modern human history; traditional "home-to-work" distance constraints, which have profoundly influenced people's choice of living places since at least the 18th century, are superseded. This is even more significant, considering that they have not been effectively overcome even by the technological advancement of means of transportation, and represents a relevant factor in the study of mobility (Acampa et al., 2024).

While considering that the choice of where to live depends on various and heterogeneous factors (home ownership, social relationships, family history, and personal preferences), the opportunities offered by the digital transition can still expand the opportunities for choosing the place (i.e., the social, economic, and environmental context) where to spend one's life, seeking liveability to increase one's well-being.

This article is part of a Research Project of Relevant National Interest (PRIN; Italian: Progetto di Ricerca di Rilevante Interesse Nazionale) approved and funded by the Ministry of University and Research (MUR), entitled "Housing mobility and digital transition. Evaluation tools and technologies for understanding current and future people's living needs, supporting territorial governance and regeneration processes". It stands as a prodromal study and investigation activity for understanding the demographic phenomenon of residential mobility, which significantly affects urbanization dynamics. These affect land use and protection, urban regeneration, and also partly energy policies and housing access, which are relevant themes in the National Recovery and

Resilience Plan (NRRP). In particular, the article presents some initial results of the aforementioned research, meeting the following objectives: *i*) understanding the concept of well-being in its multidimensional meaning, the meaning of liveability and how these two ideas interconnect, as well as examining the main indices of liveability; *ii*) proposing a procedure for the construction and weighting of a set of criteria, sub-criteria, and indicators for the assessment of liveability of a given area; *iii*) testing the procedure for the construction of a weighted taxonomy for evaluating the liveability of a place, as well as for defining benchmarks for assessing liveability levels.

Next, the literature review in Section 2 focuses on the multidimensional analysis of the change in the concept of well-being, proposing an in-depth look into the concept of liveability and how it is measured at the international level, analyzing the 4 main reports worldwide (Global Liveability Index; Global Power City Index; Innovation Cities Index; Smart City Index); Section 2 also illustrates the method of informational entropy, which aims to ensure proper weighting of criteria and sub-criteria.

Following the literature review, Section 3 defines the set of criteria, sub-criteria, and indicators for liveability assessment, proposing a hybrid approach based on the interaction between informational entropy and the detection of preferences stated through traditional social research tools. Informational entropy, first proposed by Shannon in 1948 and gradually introduced into many scientific fields, is used to explore the degree of order of a system, here initially represented by the items in the abovementioned indices. Thus, this hybrid approach consists of 3 consequential steps: *i*) de-structuring of the 4 international indices; *ii*) taxonomic re-aggregation of the liveability factors; *iii*) weighting of the taxonomy through informational entropy.

This procedure allowed defining and weighting a set of 132 sub-criteria (sub-criteria and indicators, subdivided into 13 thematic categories or criteria), using a sample of 100 interviews. The results are discussed in Section 4; in Section 5, the conclusions of the present work are drawn, and limitations and future improvements are identified.

2. MATERIALS AND METHODS

It is now generally acknowledged that GDP alone does not provide a complete picture of people's well-being (Layard, 2005b; Bartolini and Bilancini, 2010; Easterlin, 2013). In the past, economic growth has been considered a priority for maximizing societal well-being; however, to date, the direct correlation between economic growth and perceived well-being of citizens is low and/or negligible, even at average levels of wealth. Indeed, there is evidence that in developed countries, increased economic prosperity may even be associated with increased rates of depression, divorce, and suicide (Helliwell, 2007). Following these deductions, it is clear that well-being is closely related to contextual conditions (place), and thus to the objective and subjective factors that characterize it (liveability). Based on the above, a literature review on the multidimensional concept of well-being and liveability is proposed to respond to the first objective of this article. This is followed by an analysis of the main indices for measuring liveability in the international arena to construct a taxonomy on the liveability conditions of a territory. Finally, the hybrid-type approach based on the interaction between informational entropy and preferences stated through traditional social research tools for the construction and weighting of the taxonomy is illustrated.

2.1 Well-being and liveability (or residential well-being)

The concept of well-being has been a hot topic in the analysis of quality of life throughout the world's territories since the second half of the 20th century (Larson, 1978; Veenhoven and Ehrhardt, 1995). For a long time, it was believed that the well-being of a population was linked to income and therefore to the GDP of its country (Blanchard et al., 2016), the economist Easterlin developed the "happiness paradox" in 1974. He argued that the increase in income and material well-being of a society does not produce a directly proportional increase in people's happiness (Easterlin, 1974).

This theory was later confirmed by Inglehart and Klingemann (2000): they compared a plurality of countries at a defined point in time, as a function of their respective per capita income. This showed a positive correlation for the happiness index up to an income threshold of about $15,000; then, the values appear more dispersed, and the relationship between income and happiness stabilizes, as evidenced by the flat regression line (Fig. 1) (Inglehart and Klingemann, 2000).

However, the results of such studies were not new; the psychologist Maslow, as early as the 1950s, had intuited the nondependence between wealth and well-being. A founder of humanistic psychology, he is known for his "hierarchy of needs" theory (Maslow, 1954), which analyzes the factors affecting individuals in their pursuit of happiness and subjective well-being. According to this theory, human needs are hierarchized in a five-level pyramid, as follows (from bottom to top): physiological, safety, love, esteem, and self-actualization (Fig. 2).

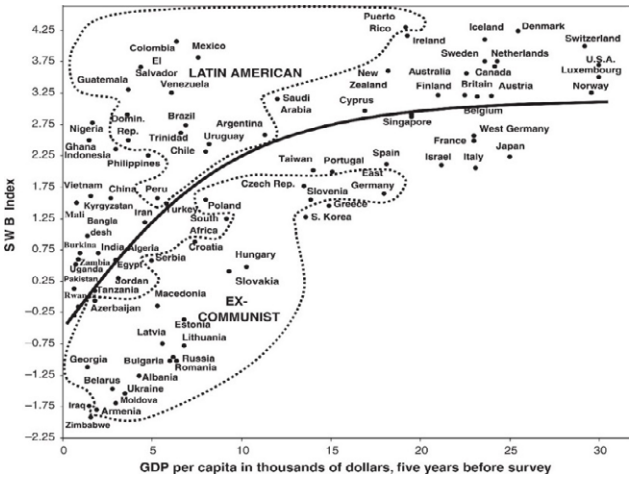

Figure 1. Inglehart and Klingemann (2000). Subjective well-being (SWB), per capita gross domestic product (GDP), and different types of societies.

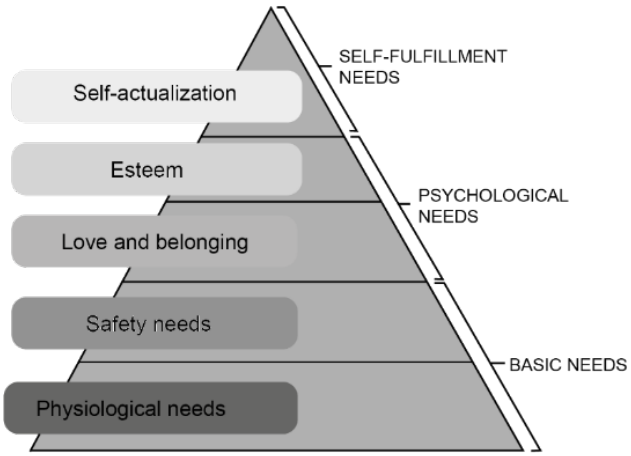

Figure 2. Maslow (1954). Motivation and personality (Authors' elaboration).

The theory exposes the limitations inherent in the use of money: the latter allows for the complete satisfaction of basic needs, while it fulfills social or self-related needs to a limited or even no extent. It follows that, regarding high standards of living, money will play an increasingly marginal role in one's definition of well-being and happiness.

These reflections show that well-being depends on heterogeneous and complex factors and cannot be separated from its context, i.e., from liveability (Cummins, 2000; Jeffrey et al., 2018; Sen, 1999).

The liveability of an area is defined as a function that correlates environmental characteristics (objective and intrinsic) and personal characteristics (subjective, social, and place attachment) (Pacione, 1990; Ahmed et al., 2019). To date, the concept of "liveability" is widely debated and difficult to understand, as there can be multiple interpretations of it. To express the concept of "liveability", the field of urban planning often uses the terms "quality of life" and "well-being", which are sometimes substituted for each other. Although they are interrelated, liveability directly refers to a place and its conditions: it indicates the presence and quality of services in built and natural environments (Ahmed et al., 2019). It is highly dependent on the prevailing context and values within the community, whether they are economic, social, or cultural (Okulicz-Kozaryn and Valente, 2018; Viviani, 2016). Consequently, it can be said that a resident's desire for a place determines the degree of liveability of that place (de Chazal, 2010; Lyndhurst, 2004).

Liveability, and thus residential well-being, can thus be positively and negatively affected by numerous factors, which we attempt to summarize below: spatial characteristics (architectural and urban design); human and social characteristics (population and type of social relations); functional characteristics (available services); contextual characteristics (lifestyle, pollution/health, maintenance, and care) (Bonaiuto et al., 2015; Bonaiuto and Alves, 2012). Citizens' experience within their neighborhood appears to be influenced by its physical characteristics (Amérigo and Aragonés, 1990). When analyzing spatial characteristics, housing type, for example, appears to significantly affect housing well-being: the presence of single-family houses is associated with a higher level of well-being than townhouses or condominiums (Evans et al., 2003; Freeman, 1984). Spatial distances within the neighborhood have a direct impact on social interactions as well as safety (Abass and Tucker, 2018; Abu-Ghazzeh, 1999). In addition, people who live in well-designed environments that provide comfort, safety, and good air quality tend to have higher life satisfaction and lower levels of psychological stress (Evans, 2003). Moreover, the availability of shared public services (social characteristics) facilitates social connectedness, particularly if they have good location and visibility. (Francis et al., 2012). The presence of urban green spaces (contextual characteristics) is relevant to residential well-being, too. This term covers heterogeneous places, such as parks, community gardens, cemeteries, roof gardens, vertical gardens, lawns, street trees, and small green structures designed as green infrastructure. A growing body of research highlights the relationship between urban green spaces (UGS) and various dimensions of well-being (Syamili et al., 2023; Maas et al., 2006). These are just a few of the factors that contribute to the liveability of a place; field studies show that the correspond-

ence between characteristics of the environment and the activities of people must be studied through a holistic and integrated system to obtain practical indications and guidelines for improvement interventions (Battisti et al., 2017; Bonaiuto et al., 2009).

In the European context, the assessment of residential well-being to date is a widely debated topic due to changing habits and lifestyles (ISTAT, 2024; United Nations, 2015; Gössling et al., 2012). For example, the Covid-19 pandemic accelerated the digitization process by several years, giving digital technologies a central role in daily life and giving rise to a new era of digital transition (Melluso et al., 2020). Traditional processes of innovation and development have been enhanced, and new forms of innovation have been created, concerning every segment of society. The detachment from the workplace and the online availability of many services (e-commerce, online citizen services, etc.) have enabled users to improve their lifestyles by decreasing their time schedules and thus fostering self-care. Moreover, these factors have set the stage for potential decentralization from urban centers, where most workplaces, businesses, services, etc., are located (Felici et al., 2022). In this context, measuring liveability becomes a matter of scientific interest and requires an approach that is as shared and objective as possible.

2.2 The measurement of liveability at the international level

In the early 2000s, various studies and analyses were already being conducted regarding liveability in various urban settings. These have generated international initiatives involving leading bodies, such as the Organisation for Economic Co-operation and Development (OECD) and the United Nations (UN). The latter has actively participated in the debate on the measurement of well-being by presenting concrete proposals, such as, respectively, the "Better Life Index" and the "17 Sustainable Development Goals", defined by the UN and applied by all member countries (Speroni, 2019). To monitor well-being, various experiments have been developed in recent years, including the Global Liveability Index, the Global Power City Index, the Innovation Cities Index, and the Smart City Index. These analyses, which are summarized in annual reports, use concrete, reliable, and measurable indicators and also consider several factors that comprehensively describe the multidimensionality of urban liveability and well-being. Therefore, these approaches, of recognized relevance and validity in the international arena, are useful for the taxonomic definition of criteria and indicators for assessing liveability.

Global Liveability Index

The Global Liveability Index is an annual ranking published by the Economist Intelligence Unit (EIU, a division of The Economist Group), which evaluates the quality of life in 173 global cities. The methodology adopted for this evaluation is based on the integration of qualitative and quantitative indicators for a detailed and complex analysis focused on critical elements such as the quality of public services, personal safety, and the resilience of urban infrastructure (Economist Intelligence Unit, 2023). Data collected annually show how political stability and social security are determinants of a city's quality of life, followed by factors such as the quality of infrastructure and access to educational services (OECD, 2021).

Global Power City Index

The Global Power City Index (GPCI) is an index developed by The Mori Memorial Foundation's Institute for Urban Strategies. It rates and ranks the world's major cities based on their "magnetism", or ability to attract international people, capital, and businesses (The Mori Memorial Foundation, 2023). The index is coordinated by an Executive Committee, which includes a diverse group of experts from various disciplinary backgrounds, and an Operating Committee dedicated to detailed and meticulous analysis of the collected data. To ensure the objectivity and credibility of the classifications, the GPCI is also supported by external auditors. These professionals verify the accuracy and integrity of the data collected and provide advice and recommendations for possible improvements to the index. The GPCI's aim is not limited to simply ranking cities: it provides an in-depth analysis of their strengths and areas of vulnerability and identifies emerging challenges facing global cities.

This index measures urban magnetism across six key functions: Economy, Research and Development, Cultural Interaction, Liveability, Environment, and Accessibility, offering a multidimensional and comprehensive view of urban competitiveness.

Innovation Cities Index

The Innovation Cities Index is an index developed by 2Thinknow within the Innovation Cities Program to rank cities based on their ability to foster innovation and competitiveness through technological, economic, and cultural factors. This index focuses mainly on aspects of digital connectivity, the presence of innovation infra-

structure, the quality of education, and the ability to attract talent to measure how well cities can stimulate and host innovative initiatives. It aims to provide a solid and comparable basis for analyzing cities' innovative capabilities, enabling analysts and decision makers to identify strengths, areas for improvement, and opportunities for targeted interventions.

Smart City Index

The Smart City Index, created by the IMD World Competitiveness Center in association with World Smart Sustainable Cities Organization (WeGO), an international consortium involving local government entities, is designed to act as a practical tool in the field of urban planning and management, emphasizing the importance of city perceptions through targeted surveys (IMD, 2023). Surveys are essential for understanding specific cities; therefore, questions are carefully worded to reflect the unique context of each city analyzed. For editions through 2021, the index relied on national Human Development Index (HDI) data provided by the United Nations Development Programme (UNDP) to integrate the perceptions collected with objective development indicators. Then, in 2022, the adoption of HDI data collected at the city level was experimented with to obtain a finer and more accurate understanding of city-specific socioeconomic conditions. This transition to more localized data aims to strengthen the accuracy of the index, enabling a more direct and meaningful assessment of the effectiveness of smart city policies and urban quality of life.

2.3 Informational entropy and detection of stated preferences

As already anticipated, the proposed study involves the definition of a set of criteria, sub-criteria and indicators to assess the liveability of a place. Following an analytical analysis of the above-mentioned international measurement methods followed by their de-structuring (Section 3.1) and subsequent taxonomic recomposition (Section 3.2), the selected sub-criteria are weighted through a hybrid approach, based on stated preferences obtained through social research methods and the application of the "informational entropy" method.

This "entropic" method is particularly useful for the proposed experimentation, as it allows for efficient management of the complexity arising from multiple indicators. The following is a summary of the method's origin and structure.

Information theory was formulated by Shannon in 1948 in his paper "A Mathematical Theory of Communication", in which he addressed the problem of optimizing a communication network. The system for quantifying information identified by Shannon turns out to be identical in form and properties to entropy, a quantity known in thermodynamics. Let H be an entropy function. The only variables on which H can depend are the probabilities of the different possible events. The original definition is given as $H(p_1, p_2, \ldots, p_n)$, as a function of a generic discrete random variable X, which can be realized in n different possible events with respective probabilities $p_1, p_2, \ldots, p_n$. Entropy allows us to measure how close or far the probability distribution is from the uniform case. In other words, if a system has high entropy, its state is shrouded in as much uncertainty as possible. By contrast, low entropy corresponds to less freedom of change and thus preferential configurations among its options, making it more predictable. Uncertainty about a system state is interpreted as a quantity of the system itself, rather than as a cognitive limitation of the observer.

The properties that characterize the theory are three:

1. H (...) is a continuous function of each of the p_i probabilities;
2. If the p_i probabilities are all equal $(p_i = 1/n)$, H takes its maximum value, since it represents the condition of maximum uncertainty about the result of variable X. This maximum value must be a monotonically increasing function of the number n of possible states;
3. If the possible events of variable X are separated into n disjoint subsets, the total entropy H must be a weighted composition of the H_i entropies of the individual subsystems. This property is called consistency.

Given these three properties, Shannon verifies that there is only one proper function and that it must have the following form:

$$H(X) = -\sum_{i=1}^{n} P(x_i) log_b P\left(x_i\right) \quad (1)$$

Let p_i be the probability of event x_i.

The methodological application process is divided as follows:

1. Identify the random variable X, i.e., the set of possible states of the analyzed system. This may represent, for example, a series of experimental measurements, discrete events in a decision-making process, or frequency distributions of observed data (Cover and Thomas, 2006);

2. Define the probability distribution associated with the random variable. If the system has n distinct states $\{x_1, x_2, ..., x_n\}$, the probability of each state is calculated as:

$$p_i = \frac{frequency\ of\ x_i}{\sum_{j=1}^{n} frequence\ of\ x_j} \quad (2)$$

Let p_i be the normalized probability of each state. The above formula allows the calculation of entropy.

This method requires information directly collected from a significant sample of subjects. To this end, social research uses various methodologies to analyze behaviors, opinions, and dynamics within a society. Among them is the survey method, a fundamental tool for collecting data (quantitative or qualitative) from many individuals. It is widely recognized for its ability to provide structured and comparable information regarding a large number of individuals (Delli Zotti, 2020). The method generally involves the use of standardized questionnaires, which allow the systematic collection of quantitative data, facilitating results processing (Babbie, 2021).

One of the key aspects in the use of surveys is the design of the questionnaire, which must ensure the validity and reliability of responses (Groves et al., 2009). Questionnaires can be administered through many channels, including face-to-face, telephone, or online interviews, with varying implications for the quality and representativeness of the sample (Couper, 2008). The wording of questions, choice of measurement scales, and response format significantly affect the quality of the collected data (De Leeuw et al., 2012). In addition, according to some studies, the use of structured questionnaire interviews is particularly effective when the research objective is to assign scores to certain criteria (Fowler, 2014).

3. METHODOLOGICAL PROPOSAL

The proposed method consists of two stages; the first stage involves the taxonomic analysis of the 4 liveability indices selected in the previous Section (Section 2.2) and thus the de-structuring of the sub-criteria that constitute them; the second phase involves the recomposition of a set of criteria, sub-criteria, and indicators inherent to the theme of liveability and residential well-being. First, it involves the definition of a questionnaire to be submitted to a substantial and heterogeneous number of individuals, and, secondly, the weighting of the results obtained through informational entropy.

3.1 De-structuring of the 4 international indices

The study focuses on four multidimensional approaches that collect data and define indicative parameters for the Global Liveability Index, Global Power City Index, Innovation City Index, and Smart City Index. Data and results of each report analyzed below refer to the year 2023, the latest available as of this article's writing date.

EIU: The Global Liveability Index

The methodology adopted for this assessment is based on the integration of qualitative and quantitative indicators that allow for a detailed and complex analysis focused on critical elements such as the quality of public services, personal safety, and the resilience of urban infrastructure. Specifically, for ranking urban liveability, the EIU employs more than 30 criteria, distributed into five main categories (criteria): *i*) stability, *ii*) health care, *iii*) culture and environment, *iv*) education, and *v*) infrastructure (Table 1). Each criterion for a given city is rated on a scale ranging from "acceptable" to "intolerable" (acceptable, tolerable, uncomfortable, undesirable, or intolerable).

This evaluation system enables precise identification of strengths and opportunities for each urban context analyzed, providing a clear and structured framework for urban policy decisions. For qualitative indicators, a score is assigned based on the judgment of internal analysts and local collaborators, while for quantitative indicators, a score is calculated based on performance relative to an external data set. The scores are then compiled and weighted to provide a score on a scale from 1 to 100, where 1 is considered intolerable and 100 is considered ideal. The liveability rating is provided both as an overall score and as a score for each category.

GPCI: Global Power City Index

The Global Power City Index (GPCI) developed by the Institute for Urban Strategies, owned by The Mori Memorial Foundation, measures "urban magnetism" through six key criteria: *i*) economy, *ii*) research and development, *iii*) cultural interaction, *iv*) liveability, *v*) environment, and *vi*) accessibility (Table 2), offering a multi-dimensional and comprehensive view of urban competitiveness. Each of these functions is divided into various groups of sub-criteria, for a total of 26 groups. These contain a total of 70 specific indicators used to analyze the characteristics and performance of

Table 1. EIU macro-indicators - Global Liveability Index (authors' synthetic graphic elaboration).

EIU - Global Liveability Index	
Stability	(a) Prevalence of petty crime; (b) Prevalence of violent crime; (c) Threat of terror; (d) Threat of military conflict; (e) Threat of civil unrest/conflict
Healthcare	(a) Availability of private healthcare; (b) Quality of private healthcare; (c) Availability of public healthcare; (d) Quality of public healthcare; (e) Availability of over-the-counter drugs; (f) General healthcare indicators
Culture and environment	(a) Humidity/temperature rating; (b) Discomfort of climate to travelers; (c) Level of corruption; (d) Social or religious restrictions; (e) Level of censorship; (f) Sporting availability; (g) Cultural availability; (h) Food & drink; (i) Consumer goods & services
Education	(a) Availability of private education; (b) Quality of private education; (c) Public education indicators
Infrastructures	(a) Quality of road network; (b) Quality of public transport; (c) Quality of international links; (d) Availability of good quality housing; (e) Quality of energy provision; (f) Quality of water provision; (g) Quality of telecommunications

Table 2. Global Power City Index: indicators of urban well-being (authors' elaboration).

GPCI - Global Power City Index	
Economy	(a) Market size: *i*) Nominal GDP; *ii*) GDP per capita. (b) Market Attractiveness: *i*) GDP growth rate; *ii*) Economic freedom. (c) Economy Vitality: *i*) Stock Market Capitalization; *ii*) World's Top 500 Companies. (d) Human Capital: *i*) Total Employment; *ii*) Employees in Business Support Services. (e) Business Environment: *i*) Wage Level; *ii*) Availability of Skilled Human Resources; *iii*) Variety of Workplace Options. (f) Ease of Doing Business: *i*) Corporate Tax Rate; *ii*) Political, Economic and Business Risk.
Research and Development (R&D)	(a) Academic resources: *i*) Number of Researchers; *ii*) World's Top Universities. (b) Research Environment: *i*) Research and Development Expenditure; *ii*) Number of International Students; *iii*) Academic Performance. (c) Innovation: *i*) Number of Patents; *ii*) Winners of Prizes in Science; *iii*) Number of Startups.
Cultural interaction	(a) Trendsetting Potential: *i*) Number of International Conferences; *ii*) Number of Cultural Events; *iii*) Cultural Content Export Value; *iv*) Art Market Environment. (b) Tourism resources: *i*) Tourist Attractions; *ii*) Proximity to World Heritage Sites; *iii*) Nightlife Options. (c) Cultural facilities: *i*) Number of Theaters; *ii*) Number of Museums; *iii*) Number of Stadiums. (d) Visitor amenities: *i*) Number of Hotel Rooms; *ii*) Number of Luxury Hotel Rooms; *iii*) Attractiveness of Shopping Options; *iv*) Attractiveness of Dining Options. (e) International interaction: *i*) Number of Foreign Residents; *ii*) Number of Foreign Visitors.
Liveability	(a) Working Environment: *i*) Total Unemployment Rate; *ii*) Total Working Hours per capita; *iii*) Workstyle flexibility. (b) Cost of living: *i*) Housing Rent; *ii*) Price level. (c) Security and safety: *i*) Number of Murders; *ii*) Economic Risk of Natural Disaster. (d) Well-being: *i*) Life Expectancy; *ii*) Social Freedom and Equality; *iii*) Risk to Mental Health. (e) Ease of living: *i*) Number of Medical Doctors; *ii*) information and communication technology (ICT) readiness; *iii*) Number of Retail Shops; *iv*) Number of Restaurants.
Accessibility	(a) International Network: *i*) Cities with Direct International Flights; *ii*) International Freight Flows. (b) Air Transport Capacity: *i*) Number of Air Passengers; *ii*) Number of Arrivals and Departures at Airports; *iii*) Station Density; *iv*) Public Transportation Use; *v*) Travel Time to Airports. (c) Transport comfort: *i*) Commuting Time; *ii*) Average Driving Speed; *iii*) Ease of Mobility by Taxi or Bicycle.

cities in detail. For each indicator, a score is calculated and aggregated at the sub-criterion level, and then further combined to obtain a score for each urban function. The sum of the scores for all urban functions determines the city's overall ranking in the GPCI, and the maximum score for a city is 2,600 points. The structure of the indicators and their weighting provides a balanced measure of the liveability, sustainability, and effectiveness of urban policies, which are crucial for land-use planning and evaluation in estimation.

IMD: Smart City Index

The IMD Smart City Index quantifies residents' perceptions of urban infrastructure and available technologies in their cities. This index includes a comparative assessment of 141 cities globally, based on the responses of 120 residents from each city. The final score assigned to each city is the result of a weighted average of the perceptions collected over the past three years, following a weight distribution of 3:2:1 for the years 2023, 2021, and 2020, respectively.

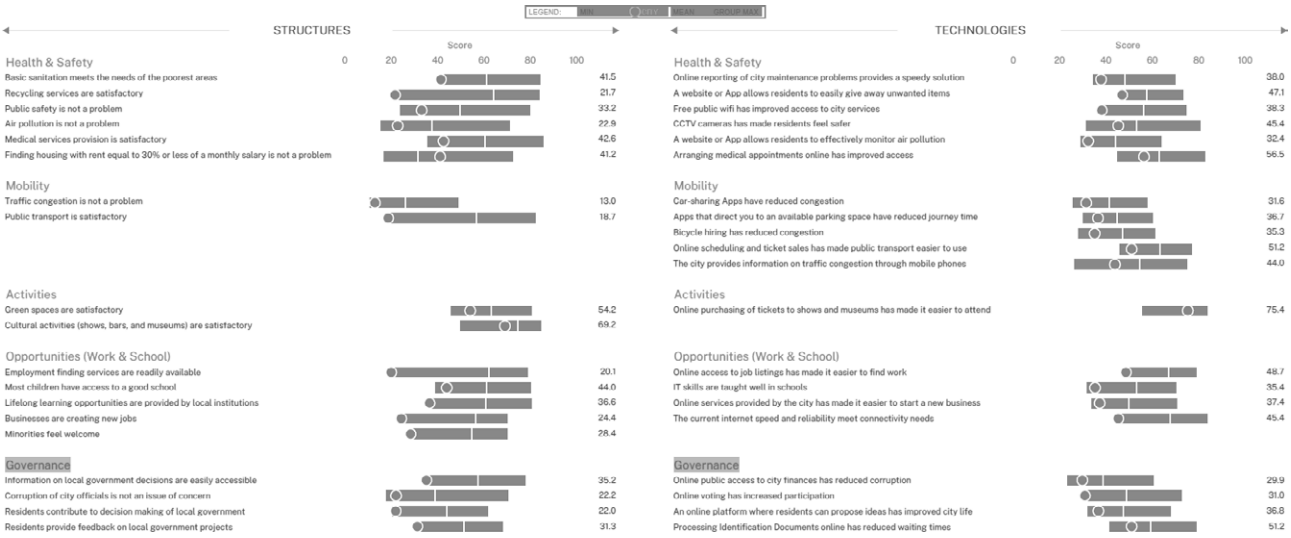

Figure 3. IMD (2023). Extract of the Smart City Index assessment of the city of Rome.

The Smart City Index methodology consists of two main evaluation pillars: Structures, i.e., the physical infrastructure of cities, and Technology, based on the technological development and digital services available to citizens. Each pillar is examined under five criteria: *i*) health and safety, *ii*) mobility, *iii*) activities, *iv*) opportunities, and *v*) governance (Fig. 3). To ensure a fair comparison, cities are categorized into four groups based on their score in the Global Data Lab's Human Development Index (HDI). Thus, cities in a higher HDI group are not compared with those in lower HDI groups. Each city within these groups is assigned a ranking that varies according to their relative perception score. These classifications are organized as follows:

1. Group 1 (highest quartile of the HDI): classifications AAA to BB (AAA-AA-A-BBB-BB)
2. Group 2 (second quartile of the HDI): classifications A to CCC. (A-BBB-BB-B-CCC)
3. Group 3 (third quartile of the HDI): classifications BB to C. (BB-B-CCC-CC-C)
4. Group 4 (lowest quartile of the HDI): classifications CCC to D. (CCC-CC-C-D)

The results are presented both as an overall ranking, placing cities from 1 to 141, and as detailed ratings for each pillar and overall. This evaluation framework facilitates an in-depth understanding of a city's ability to meet the needs of its residents through infrastructure and technology, providing essential data for urban analysis and planning in spatial and estimative assessment. An example of the evaluation structure is presented below.

Innovation Cities Index

This index allows a broad and detailed comparison between different cities globally, based on a reference dataset consisting of 500 essential data points (2Thinknow, 2023). The indicators are carefully designed to collect all variables relevant to urban innovation, thus ensuring comprehensive coverage of the dynamics and conditions that influence city development (Fig. 4). In this way, the methodology is useful both for assessments and to support the continuous improvement of urban development strategies. Again, the process goes through several steps. First, criteria that reflect key aspects of innovation are chosen; they include *i*) quality of education, *ii*) availability of human capital, *iii*) technological infrastructure, *iv*) access to services, and *v*) impact on public policy. Following data collection through government reports and field surveys, the indicators are standardized to enable comparisons between different cities worldwide.

3.2 The recomposition of the set of criteria, sub-criteria and indicators

After analyzing the index above, a set of criteria, sub-criteria and indicators for urban liveability has been developed. An exhaustive list of all the sub-criteria in the above indices, totaling 183 sub-criteria, was defined in the first stage. As they outline heterogeneous aspects of life, they have been grouped according to their area of interest, defining thirteen criteria, as follows: 1) Safety; 2) Government and Politics; 3) Market; 4) Healthcare; 5) Environment; 6) Culture; 7) Services; 8) Educa-

SECTORS COVERED

Outlined for your convenience.

Updated Sept 2023 (v4.1)

Available 2thinknow® Innovation Agency

Sector	Industries & Clusters	Government Policy Areas	2012-2022 Label
Architecture, Planning & Heritage	Construction	Architecture, Heritage, Construction, Property, Urban Planning, Building	Architecture
Arts & Culture	Culture	Arts, Culture (excluding Music)	Arts
Banking, Tax & Finance	Financial Services	Banking, Tax, Finance, Insurance, Capital Markets	Commerce
Business & Commerce	Business (B2B)	Business, Commerce, Trade, Private Enterprises	Business
Communications & Technology	High Tech	Technology, IT, Communications, Automation, Robotics, Multimedia, eCommerce	Technology & Communications
Consumer & Small Business	Consumer & Retail	Retail, Shopping, Wholesale, eCommerce	Retail
Diplomacy & Foreign Affairs	Foreign Affairs	Diplomacy, Foreign Affairs	Diplomacy & Trade
Economics & Policy	Economics & Policy	Economics, Policy	Economics
Education & Science	Education, Science & Technical	Education, Science, Engineering, Colleges, Universities, STEM	Education
Environment, Sustainability & Nature	Sustainability	Environment, Sustainability, Nature	Environment & Nature
Fashion, Clothing & Textiles	Fashion	Fashion, Clothing, Textiles	Fashion
Food, Leisure & Hospitality	Hospitality	Food, Leisure, Hospitality	Food
Geography	Geo-spatial	Geography	Geography
Government & Politics	Government & Public Services	Government, Politics	Government
Health & Medicine	Health & Life Sciences	Health, Medicine, Life Sciences, Biotech, Healthcare	Health
Industry & Manufacturing	Industrial	Industry, Manufacturing, Circular Economy	Industry
Information, News & Publishing	Communications & Media	Information, Media, News, Publishing, Books, Entertainment	Information
Labour, Employment & Workforce	Recruitment	Labour, Employment, Workforce	Labor
Law & Governance	Law	Law, Governance	Law
Logistics & Ports	Logistics	Logistics, Freight, Ports	Logistics
Military, Defence & Aviation	Defence & Aerospace	Military, Defence, Aviation, Aerospace	Military
Music & Performance	Music	Music, Performance	Music
People, Rights & Families	Community Services	People, Population, Rights, Families	People
Police, Fire & Emergency Response	Emergency Services	Public Safety, Police, Fire, Emergency Response	Public Safety
Primary Industries, Services & Energy	Agriculture, Sanitation, Water & Energy	Electricity, Gas, Agriculture, Forestry, Renewables, Farming, Food, Water Supply, Aquaculture, Horticulture	Basic Services
Religion, Multi-Culturalism & Charities	NFPs	Spirituality, Religion, Charities, Not-for-Profits, Multi-Cultural	Spirituality
Resources, Mining, Oil and Gas	Resources	Resources, Mining, Oil, Gas	Resources
Sports, Wellbeing & Fitness	Sports	Sports, Wellbeing, Fitness, Gyms	Sports
Start-Ups & Enterprise	Start-Ups & Enterprise	Start-Ups, Entrepreneurs	Start-Ups
Tourism & Travel	Travel	Tourism, Travel, Conferences, Airports	Cultural Exchange
Transport, Roads & Mobility	Transport & Automotive	Transport, Rail, Automobiles, Cycling, Personal Mobility	Mobility

Figure 4. Extract of the Innovation Cities Index.

tion; 9) Tourism; 10) Communication and Technology; 11) Infrastructure; 12) Architecture; 13) Economy and Finance.

Since some aspects mentioned throughout the sub-criteria refer to similar concepts, a taxonomic recomposition of these has been carried out. Accordingly, the Table 3 has been further rationalised by aggregating similar sub-criteria under one sub-criterion. This reorganisation process allows the definition of a structured list of 132 sub-criteria (well-being indicators). Finally, a specific unit of measurement is assigned to each of them, allowing the multiple dimensions of urban liveability to be quantified and assessed. Through this multi-criteria approach, it is possible to interrelate the many dimensions that define liveability in relation to the place. This facilitates the identification of areas for intervention and improvement, supporting decision-making for urban planning and sustainable development projects.

The definition of the residential well-being criteria proposed in the table required a process of data selection and systematization. In particular, 51 sub-criteria were eliminated from the original table of all the criteria drawn from the previously mentioned international reports, as they were repeated two or more times and therefore not relevant to the research.

The table is organised into four parts: i) Criteria (thematic dimensions); ii) Sub-criteria (specific well-being factors); *iii*) Indicators (units of measurement); *iv*) Reference reports (source documents). This structure allows for a rigorous systematization of the evaluation process, providing a solid basis for measuring residential well-being. However, it must be noted that although much data is readily available through official sources or standardized tools, for others, the availability of information may be more limited. Some sub-criteria would require further studies regarding data collection, particularly for subjective aspects related to the individual's perceptions.

Table 3. Well-being indicators: criteria, sub-criteria, indicators and reference reports.

Well-being indicators			
Criterion	Sub-criterion	Indicator	Reference report
1. Safety	1.1 Micro-crime	%	EIU Indicator
	1.2 Violent crime	%	EIU Indicator, GPCI 2023
	1.3 Military conflicts	qualitative	EIU Indicator
	1.4 Protests and activism	%	EIU Indicator, Innovation Cities Index
	1.5 Threat of natural disasters	qualitative	Innovation Cities Index
	1.6 Health emergency locations	n.	Innovation Cities Index
2. Government and Politics	2.1 Government responsiveness	qualitative	Innovation Cities Index
	2.2 Government stability	years	Innovation Cities Index
	2.3 Political transparency	%	Innovation Cities Index
	2.4 Professionalism of public employees	qualitative	Innovation Cities Index
	2.5 Level of corruption	qualitative	EIU Indicator
3. Market	3.1 Total unemployment rate	%	GPCI 2023
	3.2 Working hours per capita	h	GPCI 2023
	3.3 Work style flexibility	%	GPCI 2023
	3.4 Average housing prices	€/m²	GPCI 2023, revisited
	3.5 Handicrafts	%	Innovation Cities Index
4. Healthcare	4.1 Private healthcare	%	EIU Indicator, Innovation Cities Index
	4.2 Public healthcare	%	EIU Indicator, Innovation Cities Index
	4.3 Over-the-counter drugs	d	EIU Indicator
	4.4 Healthcare staff	n.	Innovation Cities Index
	4.5 Health emergencies	%	Innovation Cities Index
	4.6 Population well-being	%	Innovation Cities Index
	4.7 Life expectancy	years	GPCI 2023, Innovation Cities Index
	4.8 Mental health	MH	GPCI 2023
5. Environment	5.1 Relative humidity	%	EIU Indicator, Innovation Cities Index
	5.2 CO_2 emissions per capita	CO_2/eq	GPCI 2023, Innovation Cities Index
	5.3 Thermal comfort	°C	GPCI 2023
	5.4 Noise pollution	dBA	Innovation Cities Index
	5.5 Water quality	service area	GPCI 2023, Innovation Cities Index
	5.6 Air quality	qualitative	GPCI 2023, Innovation Cities Index
	5.7 Nature	service area	Innovation Cities Index
	5.8 Urban green space	%	GPCI 2023, Innovation Cities Index
	Green businesses	n.	Innovation Cities Index
	5.10 Renewable energy tariff	-	GPCI 2023
	5.11 Waste recycling rate	%	GPCI 2023
	5.12 Urban cleanliness	%	GPCI 2023
6. Culture	6.1 Cultural activities	n.	GPCI 2023, EIU Indicator
	6.2 Religious freedom	%	EIU Indicator, GPCI 2023
	6.3 Gender equality	%	Innovation Cities Index
	6.4 Citizen rights	qualitative	Innovation Cities Index
	6.5 Press freedom	qualitative	EIU Indicator
7. Services	7.1 Sports facilities availability	n./%	EIU Indicator, GPCI 2023
	7.2 Business activities	n./%	EIU Indicator, GPCI 2023, Innovation Cities Index.
	7.3 Youth activities	n./%	Innovation Cities Index, GPCI 2023
	7.4 Cultural assets	%	GPCI 2023
	7.5 Number of hotels	n./%	Innovation Cities Index
	7.6 Postal services	n./%	Innovation Cities Index
	7.7 Department stores	n./%	Innovation Cities Index

(Continued)

Table 3. (Continued).

Well-being indicators			
Criterion	Sub-criterion	Indicator	Reference report
8. Education	8.1 Private education	n.	EIU Indicator
	8.2 Public education	n.	EIU Indicator
	8.3 Quality of private education	qualitative	EIU Indicator
	8.4 Quality of public education	qualitative	EIU Indicator
	8.5 Academic performance	%	GPCI 2023
	8.6 Number of researchers	n.	GPCI 2023
	8.7 Number of international students	n.	GPCI 2023, Innovation Cities Index
	8.8 University supply	n.	Innovation Cities Index
	8.9 Research and development funds	€	GPCI 2023
	8.10 Global ranking of universities	qualitative	GPCI 2023
	8.11 Number of patents	n.	GPCI 2023
	8.12 Award winners in science and technology	n.	GPCI 2023
9. Tourism	9.1 Availability of tourist information	-	Innovation Cities Index
	9.2 Number of tourists	n.	Innovation Cities Index
	9.3 Multilingual city/language	n.	Innovation Cities Index
	9.4 Tourist attractions	%	GPCI 2023
10. Communication and Technology	10.1 Adoption of new technologies	%	Innovation Cities Index
	10.2 Broadband internet	service area	Innovation Cities Index
	10.3 Landline telephone network	service area	Innovation Cities Index
	10.4 Mobile phone network	n.	Innovation Cities Index
	10.5 Public wireless internet	%	Innovation Cities Index
	10.6 Smart working	%	Innovation Cities Index
	10.7 E-commerce sales	%	Innovation Cities Index
	10.8 Internet users	%	Innovation Cities Index
	10.9 ICT readiness	%	GPCI 2023
	10.10 Government IT policy/digital infrastructure	qualitative	Innovation Cities Index, EIU Indicator
	10.11 Metaverse	%	Innovation Cities Index
	10.12 Mass transportation automation	%	Innovation Cities Index
	10.13 Smart devices	qualitative	Innovation Cities Index
11. Infrastructure	11.1 Quality of the road network	qualitative	Innovation Cities Index, EIU Indicator
	11.2 Car sharing	n.	Innovation Cities Index
	11.3 Traffic accidents	%	GPCI 2023
	11.4 Road signs	qualitative	Innovation Cities Index
	11.5 Number of stations	n.	GPCI 2023
	11.6 Use of public transportation	%	GPCI 2023
	11.7 Commuting time	min	GPCI 2023
	11.8 Travel time to airports	min	GPCI 2023
	11.9 Availability/frequency of public services	service area	Innovation Cities Index
	11.10 Quality of public transportation	% satisfaction	Innovation Cities Index, EIU Indicator
	11.11 Ease of cab mobility	n.	GPCI 2023, Innovation Cities Index
	11.12 Presence of international airports	n.	Innovation Cities Index
	11.13 Cities with direct international flights	n.	GPCI 2023
	11.14 Number of arrivals and departures at airports	n.	GPCI 2023
	11.15 Airport transfers	n.	Innovation Cities Index
	11.16 Transportation accessibility	%	Innovation Cities Index
	11.17 Walkable city	route density	Innovation Cities Index
	11.18 Bikeable city	route density	Innovation Cities Index
	11.19 Quality of energy supply	service area	EIU Indicator

(Continued)

Table 3. (Continued).

Well-being indicators			
Criterion	Sub-criterion	Indicator	Reference report
12. Architecture	12.1 Architectural stratification	%	Innovation Cities Index
	12.2 Decorative characteristics of buildings	qualitative	Innovation Cities Index
	12.3 Green architecture	%	Innovation Cities Index
	12.4 Historical architecture	n.	Innovation Cities Index
	12.5 Quality of neighborhoods	%	Innovation Cities Index
	12.6 Vertical constructions	n.	Innovation Cities Index
	12.7 Public meeting spaces	n.	Innovation Cities Index
	12.8 Good-quality accommodation	qualitative	EIU Indicator
	12.9 New construction technologies	qualitative	Innovation Cities Index
13. Economy and Finance	13.1 Nominal GDP	€	GPCI 2023
	13.2 GDP per capita	€	GPCI 2023
	13.3 GDP growth rate	%	GPCI 2023
	13.4 Stock market capitalization	€	GPCI 2023
	13.5 Employment rate	%	GPCI 2023
	13.6 Salary level	€	GPCI 2023
	13.7 Professional Services	%	Innovation Cities Index
	13.8 Economic freedom	qualitative	GPCI 2023
	13.9 Banking stability	CAR/LCR/ROA	Innovation Cities Index
	13.10 Corporate income tax	%	Innovation Cities Index
	13.11 Accessibility to finance for growing businesses	%	Innovation Cities Index
	13.12 Acceptance of major credit cards	%	Innovation Cities Index
	13.13 Start-up	n.	Innovation Cities Index, GPCI 2023
	13.14 Economic risk of natural disasters	risk	GPCI 2023
	13.15 Employees in business support services	n.	GPCI 2023
	13.16 Availability of qualified human resources	%	GPCI 2023
	13.17 Variety of options in the workplace	%/n.	GPCI 2023
	13.18 Political, economic and business risk	risk	GPCI 2023
	13.19 Cryptocurrency	%	Innovation Cities Index
	13.20 Currency exchange	RER	Innovation Cities Index
	13.21 Headquarters of multinational corporations	%	Innovation Cities Index
	13.22 Value-added tax	%	Innovation Cities Index
	13.23 Advertising in the media	%	Innovation Cities Index
	13.24 Business approach	qualitative	Innovation Cities Index
	13.25 Designers	%	Innovation Cities Index
	13.26 Industrial diversity	%	Innovation Cities Index
	13.27 Professional services	%	Innovation Cities Index

4. EXPERIMENTATION AND RESULTS

4.1 Weighting by informational entropy (applied to surveys)

To identify the most relevant well-being indicators of liveability, a systematic review of the indices underlying the experiment has been conducted. 132 sub-criteria belonging to different criteria (thematic dimensions of well-being) have been defined; social categories with a direct interest in residential well-being (students, workers, immigrants, senior citizens, etc.) have been identified. Then, questionnaires were administered regarding the perceived relevance of the indicators with a numerical scale from 1 to 10 to weigh the criteria according to their importance. The attribution of different weights to each sub-criterion by the survey sample generates informational entropy; that is, given the variability of the data obtained, a situation of informational uncertainty occurs, possibly leading to unclear and unmanageable

results. The decision matrix $A = (a_{ij})_{nxm}$ generated from the collected data is defined and normalized into the matrix $R = (r_{ij})_{nxm}$ through appropriate formulas. The R matrix is converted to the matrix $P = (p_{ij})_{nxm}$ using the normalized values, and the entropy attributed to the equivalent indicators is calculated. Finally, attribute weighting takes place. Since the entropic method attaches more importance to sub-criteria with more variability in respondents' responses (high entropy) and less importance to sub-criteria with less variability (low entropy), the theoretical method based on entropic information is supplemented with the simple weighted and normalized mean of the scores for each sub-criterion. This is because, if all (or most) respondents attribute the highest score to a specific sub-criterion, it must have a high final weight since it reflects an important aspect for the social groups surveyed (Guarini et al., 2014; Guarini and Battisti, 2014).

Surveys

The experimentation surveyed a sample of 100 individuals from heterogeneous social groups in terms of employment and educational status. Therefore, the following groups of respondents were considered: *i*) on-campus students, *ii*) off-campus students, *iii*) smart workers, iv) non-smart workers, v) NEETs (not in employment, education or training), and vi) retirees. To assign a weight to each well-being sub-criterion, questionnaires are administered to respondents regarding the evaluation by importance of the sub-criteria; the importance scale consists of Irrelevant; Unimportant; Slightly important; Moderately important; Neither important nor unimportant (neutral); Somewhat important; Important; Very important; Fundamental; Essential. Next, the interview results were converted into numerical values from 1 to 10.

Figure 5 summarizes the average scores attributed to each of the 13 thematic categories. Environmental quality, market-related factors, and healthcare emerge as the most valued dimensions, reflecting the priority attributed to sustainability, economic vitality, and health infrastructure in determining residential well-being. Conversely, criteria such as tourism and governance are perceived as having a more marginal impact on daily life.

Entropy calculation

As a result of the data collected through the questionnaires referring to the various categories of selected individuals, some sub-criteria with heterogeneous opinions, which must be focused on, are highlighted. Thus,

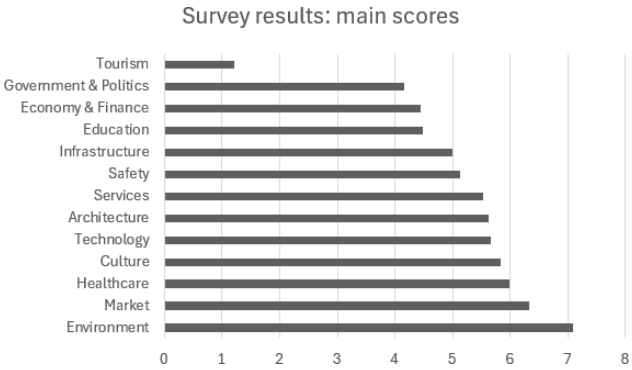

Figure 5. Survey results: main scores.

weights are determined by considering: *i*) the variability of the answers given by the respondents; *ii*) the importance that respondents give to each indicator.

The procedure proposed and explained in Section 2.3 is applied to weight the various sub-criteria optimally and minimize errors with the following assumptions:

- High entropy (≥0.6) and high mean (≥0.6) → High weight;
- Low entropy (< 0.6) and high mean (≥ 0.6) → High weight;
- High entropy (≥ 0.6) and low mean (< 0.6) → Moderate weight;
- Low entropy (< 0.6) and low mean (< 0.6) → Low weight.

First, each indicator was normalized to standardize the data in the decision matrix. The following formula was used:

$$\beta_i = \frac{x_i - min(x_i)}{max(x_i) - min(x_i)} + \pi \tag{3}$$

where:

- x_i represents the response given by unit i for the indicator
- $min(x_i)$ and $max(x_i)$ are the minimum and maximum values (1 to 10), respectively
- π is a constant to ensure that β_i is always different from zero

Then, the entropy for each indicator is calculated as:

$$H(X) = -\sum_{i=1}^{n} P(x_i) log_b P\left(x_i\right) \tag{4}$$

Below is the table of standardized well-being indices (Table 4).

The percentages obtained are a determinant for defining liveability criteria because they provide a quantitative measure of the survey participants' perceived relevance.

Table 4. Data standardisation and results processing for informational entropy.

Results and weighting						Results and weighting					
Indicator no.	Entropy	Mean (min/max)	Weight (0-1)	Weight (%)	Weight (qualitative)	Indicator no.	Entropy	Mean (min/max)	Weight (0-1)	Weight (%)	Weight (qualitative)
Ind. 1.1	0.87	0.61	0.865	1.51	High	Ind. 7.7	0.48	0.71	0.400	0.70	High
Ind. 1.2	1.00	0.55	0.573	1.00	Moderate	Ind. 8.1	0.56	0.14	0.183	0.32	Low
Ind. 1.3	0.25	0.14	0.088	0.15	Low	Ind. 8.2	0.61	0.84	0.844	1.48	High
Ind. 1.4	0.36	0.18	0.132	0.23	Low	Ind. 8.3	0.36	0.14	0.120	0.21	Low
Ind. 1.5	0.69	0.71	0.819	1.43	High	Ind. 8.4	0.25	0.80	0.450	0.79	High
Ind. 1.6	0.69	0.71	0.819	1.43	High	Ind. 8.5	0.69	0.57	0.388	0.68	Moderate
Ind. 2.1	0.87	0.31	0.495	0.87	Moderate	Ind. 8.6	0.69	0.31	0.388	0.68	Moderate
Ind. 2.2	0.87	0.43	0.495	0.87	Moderate	Ind. 8.7	0.87	0.29	0.495	0.87	Moderate
Ind. 2.3	0.48	0.43	0.245	0.43	Low	Ind. 8.8	0.74	0.69	0.836	1.46	High
Ind. 2.4	0.56	0.24	0.213	0.37	Low	Ind. 8.9	0.87	0.43	0.495	0.87	Moderate
Ind. 2.5	0.69	0.43	0.388	0.68	Moderate	Ind. 8.10	0.36	0.22	0.144	0.25	Low
Ind. 3.1	0.69	0.73	0.831	1.46	High	Ind. 8.11	0.36	0.22	0.144	0.25	Low
Ind. 3.2	0.74	0.47	0.417	0.73	Moderate	Ind. 8.12	0.36	0.22	0.144	0.25	Low
Ind. 3.3	0.87	0.84	1.000	1.75	High	Ind. 9.1	0.25	0.00	0.045	0.08	Low
Ind. 3.4	0.56	0.82	0.462	0.81	High	Ind. 9.2	0.25	0.00	0.045	0.08	Low
Ind. 3.5	0.36	0.31	0.169	0.30	Low	Ind. 9.3	0.25	0.02	0.051	0.09	Low
Ind. 4.1	0.74	0.39	0.417	0.73	Moderate	Ind. 9.4	0.25	0.00	0.045	0.08	Low
Ind. 4.2	0.69	0.86	0.905	1.58	High	Ind. 10.1	0.56	0.67	0.376	0.66	High
Ind. 4.3	0.48	0.78	0.437	0.77	High	Ind. 10.2	0.56	0.67	0.376	0.66	High
Ind. 4.4	0.56	0.57	0.312	0.55	Low	Ind. 10.3	0.48	0.14	0.158	0.28	Low
Ind. 4.5	0.74	0.49	0.417	0.73	Moderate	Ind. 10.4	0.48	0.84	0.474	0.83	High
Ind. 4.6	0.56	0.39	0.257	0.45	Low	Ind. 10.5	0.48	0.94	0.536	0.94	High
Ind. 4.7	0.74	0.57	0.417	0.73	Moderate	Ind. 10.6	0.69	0.69	0.807	1.41	High
Ind. 4.8	0.74	0.67	0.824	1.44	High	Ind. 10.7	0.87	0.29	0.495	0.87	Moderate
Ind. 5.1	0.56	0.80	0.450	0.79	High	Ind. 10.8	0.48	0.18	0.171	0.30	Low
Ind. 5.2	0.74	0.67	0.824	1.44	High	Ind. 10.9	0.87	0.57	0.495	0.87	Moderate
Ind. 5.3	0.56	0.80	0.450	0.79	High	Ind. 10.10	1.00	0.51	0.573	1.00	Moderate
Ind. 5.4	0.48	0.84	0.474	0.83	High	Ind. 10.11	0.74	0.55	0.417	0.73	Moderate
Ind. 5.5	0.48	0.67	0.376	0.66	High	Ind. 10.12	0.74	0.45	0.417	0.73	Moderate
Ind. 5.6	0.74	0.67	0.824	1.44	High	Ind. 10.13	0.87	0.63	0.877	1.54	High
Ind. 5.7	0.56	0.71	0.400	0.70	High	Ind. 11.1	0.69	0.41	0.388	0.68	Moderate
Ind. 5.8	0.74	0.86	0.934	1.64	High	Ind. 11.2	0.87	0.33	0.495	0.87	Moderate
Ind. 5.9	0.56	0.57	0.312	0.55	Low	Ind. 11.3	0.36	0.76	0.425	0.74	High
Ind. 5.10	0.56	0.55	0.306	0.54	Low	Ind. 11.4	0.56	0.31	0.232	0.41	Low
Ind. 5.11	0.69	0.80	0.868	1.52	High	Ind. 11.5	0.87	0.73	0.938	1.64	High
Ind. 5.12	0.69	0.76	0.844	1.48	High	Ind. 11.6	0.69	0.59	0.388	0.68	Moderate
Ind. 6.1	0.69	0.53	0.388	0.68	Moderate	Ind. 11.7	0.74	0.43	0.417	0.73	Moderate
Ind. 6.2	0.69	0.43	0.388	0.68	Moderate	Ind. 11.8	0.00	0.10	0.000	0.00	Low
Ind. 6.3	0.74	0.67	0.824	1.44	High	Ind. 11.9	0.56	0.73	0.413	0.72	High
Ind. 6.4	0.74	0.61	0.787	1.38	High	Ind. 11.10	0.36	0.59	0.255	0.45	Low
Ind. 6.5	0.25	0.61	0.339	0.59	High	Ind. 11.11	0.56	0.14	0.183	0.32	Low
Ind. 7.1	0.74	0.78	0.885	1.55	High	Ind. 11.12	0.48	0.33	0.214	0.37	Low
Ind. 7.2	0.25	0.73	0.413	0.72	High	Ind. 11.13	0.56	0.22	0.207	0.36	Low
Ind. 7.3	0.69	0.63	0.770	1.35	High	Ind. 11.14	0.56	0.08	0.164	0.29	Low
Ind. 7.4	0.56	0.37	0.250	0.44	Low	Ind. 11.15	0.61	0.43	0.339	0.59	Moderate
Ind. 7.5	0.48	0.10	0.146	0.26	Low	Ind. 11.16	0.69	0.73	0.831	1.46	High
Ind. 7.6	0.69	0.41	0.388	0.68	Moderate	Ind. 11.17	0.48	0.84	0.474	0.83	High

(Continued)

Table 4. (Continued).

Results and weighting					
Indicator no.	Entropy	Mean (min/max)	Weight (0-1)	Weight (%)	Weight (qualitative)
Ind. 11.18	0.36	0.90	0.511	0.90	High
Ind. 11.19	0.87	0.27	0.495	0.87	Moderate
Ind. 12.1	0.36	0.06	0.095	0.17	Low
Ind. 12.2	0.87	0.63	0.877	1.54	High
Ind. 12.3	0.87	0.55	0.495	0.87	Moderate
Ind. 12.4	0.48	0.43	0.245	0.43	Low
Ind. 12.5	0.48	1.00	0.573	1.00	High
Ind. 12.6	0.48	0.12	0.152	0.27	Low
Ind. 12.7	0.56	0.80	0.450	0.79	High
Ind. 12.8	0.48	0.90	0.511	0.90	High
Ind. 12.9	0.87	0.43	0.495	0.87	Moderate
Ind. 13.1	0.39	0.65	0.363	0.64	High
Ind. 13.2	0.56	0.31	0.232	0.41	Low
Ind. 13.3	0.56	0.31	0.232	0.41	Low
Ind. 13.4	0.69	0.29	0.388	0.68	Moderate
Ind. 13.5	0.74	0.78	0.885	1.55	High
Ind. 13.6	0.56	0.67	0.376	0.66	High
Ind. 13.7	0.69	0.37	0.388	0.68	Moderate
Ind. 13.8	0.36	0.80	0.450	0.79	High

Results and weighting					
Indicator no.	Entropy	Mean (min/max)	Weight (0-1)	Weight (%)	Weight (qualitative)
Ind. 13.9	0.74	0.73	0.861	1.51	High
Ind. 13.10	0.25	0.00	0.045	0.08	Low
Ind. 13.11	0.56	0.20	0.201	0.35	Low
Ind. 13.12	0.69	0.43	0.388	0.68	Moderate
Ind. 13.13	0.56	0.69	0.388	0.68	High
Ind. 13.14	0.87	0.53	0.495	0.87	Moderate
Ind. 13.15	0.25	0.00	0.045	0.08	Low
Ind. 13.16	0.56	0.14	0.183	0.32	Low
Ind. 13.17	0.87	0.71	0.926	1.62	High
Ind. 13.18	0.74	0.27	0.417	0.73	Moderate
Ind. 13.19	0.87	0.33	0.495	0.87	Moderate
Ind. 13.20	0.48	0.22	0.183	0.32	Low
Ind. 13.21	0.74	0.55	0.417	0.73	Moderate
Ind. 13.22	0.74	0.37	0.417	0.73	Moderate
Ind. 13.23	0.36	0.02	0.083	0.14	Low
Ind. 13.24	0.56	0.41	0.263	0.46	Low
Ind. 13.25	0.48	0.41	0.239	0.42	Low
Ind. 13.26	0.69	0.53	0.388	0.68	Moderate
Ind. 13.27	0.25	0.12	0.082	0.14	Low

Through the interpolation of arithmetic averages and the variability of the scores assigned by the individuals surveyed, urban liveability indicators are weighted (see below, Table 4). Table 4 shows both the percentage weights of each indicator and a qualitative assessment of the sub-criteria, ranked according to their significance as previously specified: high, moderate, or low. High-importance sub-criteria total 52 and are mainly concentrated in the environmental and labor market areas. Sub-criteria with more variability in responses (entropy of 1) included violent crime (sub-criterion 1.2) and government IT policy (sub-criterion 10.10). By contrast, sub-criteria such as travel time to airports (sub-criterion 11.8) and tourist attractions (sub-criterion 9.4) generated low entropy.

5. DISCUSSIONS AND CONCLUSIONS

The results obtained in the analysis phase, involving the categories of respondents defined before, show a clear hierarchy among well-being sub-criteria. The results bring out the importance of factors such as environment, public health, and employment/unemployment agreed upon by all. This means that environmental quality, access to accessible, high-quality public healthcare, and employment opportunities are generally recognized as crucial elements of quality of life. In the environmental criterion, almost all indicators scored high, well above 0.8; in particular, good design of green and natural areas is considered crucial in the urban context. Healthcare, too, is a major factor, as it achieved very high results. Regardless of their income range, people believe that access to high-quality public health facilities is essential, especially in a post-pandemic context.

Another sub-criterion of considerable interest is smart or flexible working. This factor is considered important mainly because of the variability of the responses; in the middle-income categories, working remotely is found to be an indicator with increasing relevance compared to the others. This reflects a global trend, accelerated by the Covid-19 pandemic, in which smart working has been seen as an advantageous solution for balancing work and personal life. Although not all participants attached the same degree of importance to this factor, the general perception is that work flexibility can contribute significantly to improving personal well-being, and the indicator is important precisely because it elicits different opinions and thus deserves more debate and attention.

In contrast to the highly rated sub-criteria, factors such as tourism, the presence of facilities such as airports, or services such as hotels scored much lower. They have been considered marginal or even deleterious factors for residential well-being, especially for people in the low, low-middle, and upper-middle income categories. This could be due, for example, to the increase in housing rental and sale prices caused precisely by the strong tourist attractiveness of the place. Similarly, the presence of large facilities such as international airports negatively affects residential well-being. Although access to global infrastructure may be perceived as important in terms of economic development and mobility, its direct impact on individual well-being was found to be less significant than other factors more related to everyday life, such as access to healthcare or environmental protection. To ensure a fair assessment of the importance of the various criteria, each criterion was assigned a weight, expressed as a percentage. The methodological process included the following steps: *i*) sum of the weights assigned to the individual sub-criteria for each criterion, so that each criterion is given an overall score; *ii*) definition of each criterion's mean weight, to avoid distortions due to the different numbers of sub-criteria contained in each criterion; *iii*) conversion of the mean scores of each criterion into percentage weights. Table 5 summarizes the process.

The summary graph below provides a better visualization of the discussed data (Fig. 6).

The results suggest that public policies should focus on criteria that are most relevant to well-being, such as environment, health, and employment. In a perspective of optimization of resource allocation to achieve the highest urban benefits (Acampa and Pino, 2023), policies should be focused on improving these criteria, which are perceived as fundamental by citizens. Ecological policies, universal access to health care, and job creation are, therefore, the key areas in which to invest to increase collective well-being. Moreover, housing accessibility also appears as one of the key sub-criteria for residential well-being.

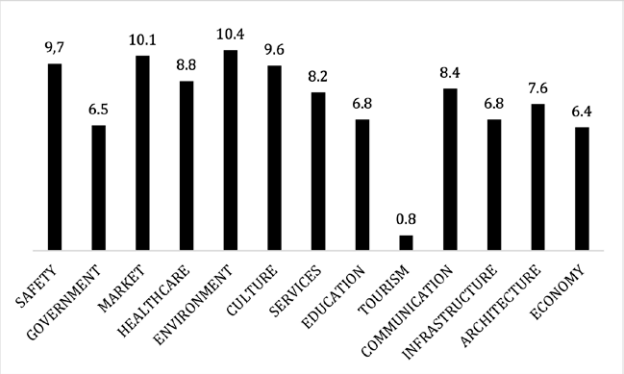

Figure 6. Percentage weights of well-being dimensions (macrocategories).

In addition, the fact that smart working is emerging as an important sub-criterion also suggests that future policies may encourage the adoption of more flexible work patterns that allow workers to better balance professional and personal needs.

The analysis of indicators of residential well-being identified the most relevant aspects for citizens' perceived quality of life. The results obtained confirm the importance of criteria such as environment, health, and

Table 5. Calculation of criterion weights.

Determination of percentage points for each criterion				
Criteria	Sum of subcriteria weights	n. of subcriteria by category	Mean weight by category	Percentage weight
Safety	5.76972	6	0.96	9.7
Government and politics	3.21448	5	0.64	6.5
Market	5.04121	5	1.01	10.1
Healthcare	6.97945	8	0.87	8.8
Environment	12.36337	12	1.03	10.4
Culture	4.77064	5	0.95	9.6
Services	5.69443	7	0.81	8.2
Education	8.10709	12	0.68	6.8
Tourism	0.32663	4	0.08	0.8
Communication and technology	10.80545	13	0.83	8.4
Infrastructure	12.90403	19	0.68	6.8
Architecture	6.81520	9	0.76	7.6
Economy	17.20831	27	0.64	6.4

market, with weights above 8.5 percent compared to the total of thirteen dimensions. These results align with the literature suggesting that environmental quality, access to healthcare, and job stability are among the main determinants of well-being. In particular, the importance attached to the environment and health reflects the growing awareness of global ecological and health challenges, while employment is perceived as a key factor in ensuring economic and psychological well-being. In terms of policy implications, the results indicate that public policies should focus on interventions that improve environmental quality, access to health services, and employment opportunities, as these factors are perceived as essential to the population's well-being. In addition, the growing relevance of remote work suggests the need to promote more flexible and inclusive work solutions that can meet the needs of an evolving world of work.

However, it is important to recognise the limitations of this study: for example, in the study, a sample of 100 persons diversified by status (e.g. students, workers and pensioners) was considered. This sample size is relatively small compared to the complexity of the phenomenon under investigation. A small sample size reduces the statistical power of the analysis and increases the margin of error, potentially obscuring significant trends or correlations. Furthermore, it may not accurately reflect the diversity of urban populations, which limits the generalisability of the results to larger or different socio-spatial contexts. Moreover, the methodology relies almost exclusively on quantitative data, yet this information could be supplemented with qualitative data, capturing the subjective nuances of how individuals perceive well-being and liveability. This could be developed through open-ended surveys, focus groups or interviews that would provide a more perceptive and emotional version of the results obtained. Finally, the timing of the survey – possibly influenced by post-pandemic perceptions – may have skewed responses on topics such as healthcare, green spaces, or remote work. In conclusion, this study has provided valuable information on how various criteria influence well-being perception for different socioeconomic categories, with important implications for the formulation of public policies geared toward improving the population's quality of life.

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CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Firenze University Press
www.fupress.com/ceset

OPEN ACCESS

Citation: Vecchiato, D., Bonardi Pellizzari, C., Dominici, A. & Tempesta, T. (2026). The impact of energy certification on the real estate market and its effect in the short-run: an analysis using Big Data and hedonic pricing. *Aestimum* 88: 51-69. doi: 10.36253/aestim-19711

Received: September 23, 2025

Accepted: January 23, 2026

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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The impact of energy certification on the real estate market and its effect in the short-run: an analysis using Big Data and hedonic pricing

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Abstract. This study analyses the effect of Energy Performance Certificates (EPC) on residential buildings in Padua (Italy). Introduced by the 2002/91/EC Directive, EPCs became mandatory in European Union countries for buildings for sale or lease. Using web-scraping we collected 5,188 real estate offers in 2022 and 2023, of which 1,738 were in the 'apartment' category and suitable for data analysis. We examined EPC effects on prices both in aggregate terms (2022–2023 combined) and by year, to test short-run stability. Results confirm previous findings: a price premium emerges as energy classes improve, with the highest values for top EPC ratings. While most housing characteristics showed stable short-run effects, EPC classes revealed a stronger and more significant impact over time, especially for lower energy classes.

Keywords: appraisal, hedonic pricing, energy, energy performance certificates, big data, web crawling.

1. INTRODUCTION

The last few decades have been marked by an unprecedented increase in energy consumption. According to the International Energy Agency's (IEA) 2021 report, demand grew even more sharply after COVID-19 years. Coupled with pressures to adopt renewable energy sources and challenges related to ongoing conflicts, such as the war in Ukraine, this has led to rising energy prices and further pressure on the energy transition (IEA, 2021).

To reduce energy consumption while maintaining performance, various technologies and policies have been developed to improve energy efficiency. In the housing sector, energy efficiency can be translated into technologies to improve the sustainability of apartments, houses, or entire buildings in terms of energy use and CO_2 emissions. Examples include solar panels, modern heating systems, efficient lighting and appliances, wall insulation, and

window frames (Nicolae and George-Vlad, 2015). These technologies are applied not only to new buildings but also to renew older dwellings, resulting in enhanced energy performance, health benefits by improving indoor temperature comfort and creating new green jobs (Meijer et al., 2012).

Energy efficiency initiatives have become increasingly important at the European Union (EU) level, where buildings account for 40% of the EU's energy consumption and 36% of energy-related greenhouse gas emissions (European Commission, 2021). To reduce energy demand and improve energy efficiency, the EU introduced the Energy Performance Certificate (hereafter EPC), a tool that allows the measurement of the dwelling's energy efficiency and its comparison with other dwellings. First mentioned in the Energy Performance of Buildings Directive (EPBD) 2002/91/EC, the EPC became mandatory in the EU member states, so any building, house or apartment must have an EPC at the time of sale or lease to inform potential buyers about the energy performance of the dwelling, with a validity of 10 years (European Commission, 2002). The directive was revised in 2010 (Directive 2010/31/EU-Recast), in 2018 (Directive 2018/2002/EU), and in 2024 (Directive 2024/1275/EU). The first laws introduced increased standards, such as stating the EPC in advertisements of dwellings and setting mandatory targets of energy coming from renewable sources (European Commission, 2010, 2018), while the last revised directive aims to achieve more ambitious climate goals, improve energy efficiency, reduce greenhouse gas emissions, and combat energy poverty. In particular, the objective is to reach the targets of cutting greenhouse gas emissions by at least 60% in the building sector by 2030 compared to 2015, while aiming for a fully decarbonized, zero-emission building stock by 2050 (European Commission, 2024). Moreover, other measures in the revised directive include the gradual introduction of minimum energy performance standards for non-residential buildings, and the increase in the average energy performance of the national residential building stock by 16% by 2030 (compared to 2020), and 20-22% by 2035, based on national trajectories (European Commission, 2024).

As an EU member state, Italy adopted the EPC requirements for all properties offered for sale or rent in 2005 (Legislative Decree n.192 of 19 August 2005), then made inclusions in sales and rent advertisements mandatory from 2012 (Legislative Decree n. 28 of 3 March 2011). The EU Directive 2010/31/EU was then adopted in Italy (Legislative Decree n. 63 of 4 June 2013), and the Law n.90 of 3 August 2013 established a new approach for calculating the energy performance of buildings. The Italian EPC is known as APE (Attestato di Prestazione Energetica) and rates energy performance in ten classes, from Class G (worst performance) to A4 (best performance).

Since the creation of EPC in Europe, a price premium was expected for dwellings with higher energy performance due to a greater awareness of the cost savings derived from investments in energy efficiency (Wilkinson and Sayce, 2020). In other words, EPC is not only a policy tool, but could also be a market tool in real estate. In recent decades, many studies have been carried out to analyse the influence of EPC on the listing and transaction prices of dwellings, and most of them recognize a price premium for more energy efficient properties (see the review of Ou et al. (2025)). However, the findings show greater variability in the magnitude of the results. Moreover, few authors found a weak or negligible impact of energy certifications on transaction prices (Fregonara et al., 2014; Marmolejo-Duarte and Chen, 2019a; Olaussen et al., 2017, 2021; Olaussen et al., 2019; Wilhelmsson, 2019).

Within this framework, our study aims to contribute to the debate on the impact of energy performance in the real estate market by providing new insights. In particular, our analyses aim to determine whether the EPC of apartments affects their advertised prices in the city of Padua, Italy. Padua is a medium-sized city in northern Italy, characterized by a mix of newer and older residential buildings. The presence of a major university contributes to a dynamic housing market, influenced by both short and long-term demand. This context provides a relevant setting for examining the impact of EPCs in urban environments. More specifically, our study has two objectives: *i*) to test if the EPC has an impact on the price of the dwellings; and *ii*) to test if this effect can be considered stable in the short-run, namely in a year time span (we considered the years 2022 and 2023). To this end, we leverage Big Data in real estate through web scraping algorithms. The use of web scraping in real estate research is a recent development that enables the collection of all dwellings listed for sale or rent on target websites in real time (Chapelle and Eyméoud, 2022; Grybauskas et al., 2021; Jach, 2021; Wei et al., 2022). These recent technologies involving Big Data facilitate the collection of larger samples in a shorter amount of time and help reduce mistakes associated with manual data collection (Khder, 2021). Moreover, web scraping can be a suitable approach for obtaining reliable data to analyze price dynamics in a context like Italy, where access to real transaction contracts is limited, costly, and subject to some limitations for professionals.

The remainder of this paper is structured as follows: the second section (Section 2) offers a review of the literature involving the influence of energy efficiency on dwelling values and whether there is a market premium for those presenting higher energy performance certificates, with a special focus on Italy. The third section (Section 3) includes the methodology, from data collection involving web scraping of Big Data to the regression analysis through hedonic models. The fourth section (Section 4) presents the characteristics of the housing market in the study area, and which characteristics are influential on apartments' price per m^2 in Padua, including energy efficiency. Finally, the last section (Section 5) builds on the results and presents conclusions and suggestions for further research.

2. BACKGROUND

In the literature, several studies have investigated the influence of the EPC on the real estate market. The findings provided have to be evaluated in the framework in which each study was conducted, namely considering the data used, the geographic area, the variables included, and the methodology implemented. For example, economic trends of a specific area, demography, cultural influences, and household behaviours may significantly impact real estate, limiting comparisons between different areas.

The literature reveals significant differences in how energy efficiency affects property prices depending on the type of dwelling. Evangelista et al. (2020) found that in Portugal, energy-efficient apartments (rated A and B) command higher price premiums when compared to less efficient properties, equal to 13.1% for new and 12.5% for existing units. In contrast, houses show more modest increases, with premiums of 5.7% for new and 4.6% for existing units. In the UK, Perez et al. (2025) observed that detached houses yield slightly higher capitalization coefficients for EPC bands compared to flats; however, all property types exhibit positive price premiums for higher energy performance, confirming the capitalization of EPC across the housing market. Still in the UK, McCord et al. (2020) highlighted a complex relationship between property type, energy efficiency, and price, arguing that different dwelling types have varying likelihoods of presenting a certain energy performance rating.

Besides those just mentioned, other studies in Europe also point to price premiums and show differences between residential and commercial buildings, as well as between sales and rental markets. For residential buildings, improved energy efficiency is associated with price increases of approximately 3-8%, while rental premiums range from 3-5%. The increase in prices is higher for commercial buildings, with premium prices above 10% and rental prices being positively affected by 2-5% (Zancanella et al., 2018). Other studies also suggest that premiums tend to be larger in the sales market than in the rental market. For instance, Gerassimenko et al. (2024) found that in the Belgian sales market, compared to D-rated properties, the A, B, and C-labeled dwellings have a price premium of 42.70%, 27.27%, and 11.02%, respectively. In contrast, rental premiums for A, B, and C-labeled dwellings were 13.38%, 8.97%, and 5.24%, respectively. Stenvall et al. (2022), in a study conducted in Sweden, argue that the lower premiums observed for tenant-owned apartments may be partly explained by the fact that heating costs are typically included in the monthly fee paid to the tenant association, which tends to remain stable in the short term. Beyond direct energy expenditure, this premium for energy-efficient rentals, or lower values for energy-inefficient homes, seems to have increased in recent years. This trend may be explained by EPC regulations, which enhance transparency by allowing tenants to assess energy performance prior to renting, as well as by a growing awareness of environmental issues (Pommeranz and Steininger, 2021). This capitalization of energy efficiency over time has also been observed in other rental markets, such as in the UK and the Netherlands (Chegut et al., 2020). Furthermore, the relationship between EPC ratings and price premiums may vary depending on the location of the dwelling. For instance, the premium tends to be weaker in city centres and stronger in the rural or peripheral areas of Germany and Spain, due to the housing shortage and the higher purchasing power per capita found in the city (Marmolejo-Duarte and Chen, 2019a; Taruttis and Weber, 2022). Differences were also found according to the climatic areas in Spain, with a higher premium on the asking price for the coastal area compared to the cooler climatic zone, related to weather instabilities along the coast and a worse isolation system installed in the houses (de La Paz et al., 2019).

At the country level, Taruttis and Weber (2022), using a hedonic price model with 422,242 comparables from 2009 to 2017 in Germany, found that if energy efficiency increases by 100 kWh/m^2 per year, asking prices for single-family homes increase by 6.9% on average. In the UK, a unit increase in the numerical energy performance score (from 1 to 100) showed a 0.18% increase in the transaction price per unit area (Goel, 2023). In Portugal, dwellings with better energy performance (based on EPC) had a higher transaction price per m^2, and those associated with non-green housing decreased the sales value (Koengkan and Fuinhas, 2022). In Spain, the

premium on the listing prices is equal to 1.7% for each EPC ranking (Marmolejo-Duarte et al., 2019b). However, some studies that also used hedonic models showed that EPC only modestly impacted listing prices (Fregonara et al., 2014; Marmolejo-Duarte and Chen, 2019a) or did not affect price (Olaussen et al., 2017, 2021; Olaussen et al., 2019; Wilhelmsson, 2019).

In Italy, a general picture was provided by Loberto et al. (2023), who analysing 2.5 million listings between 2018 and 2022, found that for houses with energy label A the premium is about 25% compared to houses with energy label G. However, they found a very heterogeneous effect throughout the country, partly explained by the different climate conditions that characterized different areas of Italy. Other scholars have studied the impact of EPC certification on house price focusing on specific cities or areas: Turin, Bolzano, Padua, Bari, and Reggio Calabria. The first study to analyse EPC ratings on real estate was carried out in 2014 in the city of Torino by Fregonara et al. (2014), using 577 comparables collected in 2012, the year that marked the beginning of the inclusion of EPC in advertisements for dwellings for sale in Italy. The results revealed a weak relationship between the listing price and high energy efficiency levels. An explanation for this was that potential buyers were not yet aware that a higher investment in energy-efficient houses would result in lower maintenance costs in the future, and as such, this was not reflected in the listings of real estate agencies (Fregonara et al., 2014). Later, in 2017, Fregonara et al. (2017) found the same weak relationship, but this time using real transaction data instead of listing prices. However, Dell'Anna et al. (2019) using 15,288 listing prices found that the impact of the energy class on prices in Turin was, according to the methodology implemented (hedonic price method and spatial model), equal to +6.8% and +6.3% respectively for each class jump from G to A. Therefore, considering six EPC class jumps, the maximum price increase from the lowest class (G) to the highest (A) is, respectively, 40.8% and 37.8%. This maximum price of property value decreased to 25.2% (+4.2% increase for each incremental improvement in the EPC rating scale) in a following study of Dell'Anna (2025), who used machine learning techniques on 2,783 listings. Also, Barreca et al. (2021) highlighted a price premium for Turin, with low EPC labels (E, F and G) significantly and negatively affecting listing prices (-3.3% in the hedonic model, -2.7% in the spatial model) compared to the C-D labels taken as reference, while high EPC labels (B, A1, A2, A3 and A4) present a positive influence on them (+6.2% in the spatial model). The depreciating effect on house prices caused by lower energy efficiency in Turin was recently confirmed by Loro et al. (2024), with a sample of 100 listing prices. Still in Northern Italy, Bisello et al. (2020) used hedonic models to detect the impact of EPC on 825 listing prices in Bolzano. A premium of around 6% was found for properties moving from the worst energy performance class (G) to the best (A), while the premium price for class B is almost 5%, and for class C around 2.8%. It should be noted that in the dataset analysed by Bisello et al. (2020), collected in 2018, nearly 80% of observations were in class G, while only about 10% were in class A-B.

Specifically in Padua, Copiello and Bonifaci (2015) by using the hedonic price model found not only that EPC has a statistically significant influence on house asking prices, but also that it can reach up to 21.9% of the premium price if the dwelling is class A (the highest EPC) compared to class G (the lowest EPC). The premium price detected for class B is slightly lower (+20.2%), while class C and class D increase the price by 17.4% and 17.1%, respectively. The premium price drops to 9.5% for the properties of class F and to 2.3% for level E, compared to the G class. In 2021, Copiello and Donati (2021) confirmed the trend but detected higher value magnitudes. Specifically, compared to the G label, they found a price premium of 14.8% for the F label, 24.3% for the E class, 30.1% for the D class, and 32.3% in the energy class C. For an EPC equal to B and A, the impact of listing prices is higher at 61.1% and 61.7%, respectively. More recently, Copiello and Coletto (2023), by using different models, found a premium between 54.7% and 53.4% for the A4 properties (the most efficient class) compared to class D, a premium between 42.0% and 45.3% for the A to A3 bands, and a decrease in unit price between 29.3% and 10.8% for the G band.

Moving from Northern to Southern Italy, in the city of Bari, Manganelli et al. (2019) found an impact of EPC on transaction prices, increasing the price premium moving from levels G to levels A. However, they show different dynamics according to the area of the city considered. For dwellings in the central area of Bari, the price premium slightly increases from class G to class F, then remains unchanged up to class C, until it skyrockets in class A (+29.4% compared to class G). In the suburban area of Bari, the marginal contribution of the EPC is quite constant moving from level G to level A, reaching a price premium of +45.5% for this last class. Morano et al. (2019) further investigate the role of the EPC in the transaction prices of housing in Bari, identifying premiums of 27.94% for the A level and of –26.44% for the G label with respect to a macro-aggregation of all other central EPC classes. In Reggio Calabria, a dataset of 515 comparables of residential properties derived from information communicated by direct actors, such

as buyers and sellers, promoters, realtors, agencies, and notaries, was collected and analysed by means of an evolutionary polynomial regression. The authors found a premium of 41.52% on sale prices of properties presenting the highest energy performances (EPC class A or B) (Massimo et al., 2022).

Most of the studies found in Italy used the hedonic price model as a methodological approach (Bisello et al., 2020; Copiello and Bonifaci, 2015; Dell'Anna et al., 2019; Fregonara et al., 2017), even if some of them have been integrated with spatial specifications. Considering the data source, except for a few studies that used real transactions, the most frequent approach was to rely on samples derived from listing prices, in line with findings of Fregonara and Rubino (2021), who conducted a systematic review of studies published between 2016 and 2021 investigating the relationship between energy efficiency and real estate prices. Specifically in Italy, this is explained by the challenges involved in obtaining such data, since the transaction prices are not publicly available in the country and the procedures to access and collect the transaction data make it difficult to use in hedonic models (Bisello et al., 2020; Manganelli et al., 2019).

3. MATERIALS AND METHODS

The present study applies the Hedonic Pricing Method (HPM), originally developed by Court (1939) (see also Goodman (1998)), to a dataset created using Big Data, specifically listing prices collected by web scraping (Diouf et al., 2019; Gonzalez and Erba, 2024; Khalil and Fakir, 2017) from a leading real estate advertising website in Italy. In the following subsections we will describe the data collection approach, the sample of data analysed and the specification of the hedonic models applied during data analysis.

3.1 Data collection

A custom crawler was developed in the Python programming language to collect the data used in this study. This crawler was specifically tuned to harvest real estate listings from a specialized Italian website. Data were collected focusing on residential listings in the municipality of Padua, a medium-sized city with a relatively dynamic real estate market located in the Veneto region, Northern Italy. The data collection was performed in two rounds, first on the 14^{th} of February 2022 and then on the 13^{th} of February 2023. The 2022 collection resulted in a dataset of 2,000 real estate offers, of which 1,318 fell into the 'apartment' category. The distinction is essential, as it would be incorrect to compare properties from different categories, such as apartments with detached houses or attics. Considering the 2023 data collection, the initial dataset consisted of 3,188 records, 2,000 of which were falling in the 'apartment' category. Aggregating the 2022 and 2023 datasets (3,318 records), we then performed some further data-cleaning removing all records with missing data like price or surface, and limited the final dataset to dwellings with a surface greater than or equal to 30 m^2 and a minimum price of 12,000 €. Such cleaning left 1,835 potentially usable records. From such a dataset of 1,835 real estate offers, we performed a further analysis to detect if some dwellings were unsold in 2022 and still present in the database of 2023: 97 records were present in both years and, therefore, we kept only the 2022 version of the data. The final dataset consisted of 1,738 records, 705 for the year 2022 and the remaining 1,033 for the year 2023. Therefore, from an initial dataset of 5,188 records (aggregating 2022 and 2023), only 33.5% of the data (1,738 records) was usable in our data analysis.

The use of web scraping algorithms allowed to collect a huge amount of data in a short time: the most time-consuming aspect was the development of the web-crawler, but once it was implemented it required a short time to feed a database for data analysis. Another advantage of this method is that the crawler can be used in future data collection, saving time during future research activities. Since just 33.5% of the collected data were suitable for our data analysis due to missing or incomplete data, this should be taken into consideration as a limitation. However, a similar issue could be encountered when analysing real transaction contracts, at least in Italy, where some data could be missing or difficult to understand without visiting or knowing the real estate. The greatest criticism or limitation of this data collection methodology lies on the fact that the listing price will often differ from the final transaction price of the real estate. This is because listing prices could be defined as the 'wish prices' of sellers, which can change after a proper exposure of the listing and the eventual bargain process between seller and buyer. Nevertheless, a listing price that greatly differs from the real value of the real estate would lead to delays in the selling times and, in the worst scenario, prevent the property from getting sold. According to some informal discussions with real estate agents, listing prices differ from real prices by 10% on average. This figure is supported by the Bank of Italy's quarterly report (Banca d'Italia, 2025). According to feedback from real estate agents, the average margin was 8% in Q1 2022 and 8.2% in Q1 2023. Importantly, the Bank of Italy's data indicates that the

divergence between transaction prices and listing prices exhibits both temporal and spatial variation. Despite this discrepancy with transaction prices, listing prices could offer important information about the relative value of the property characteristic and could be quite easily accessible. As a consequence of the previous consideration, the marginal prices derived in absolute (and not relative) terms from listing prices should be used with caution, while the opposite applies while doing consideration in relative terms, namely working with percentages as we did in this study.

The summary statistics of the collected data, suitable for the analysis of the hedonic pricing model, are summarized in Table 1 and Table 2 for the continuous and discrete variables, respectively. The average list price for the full sample is about €277,558.7 per housing unit (Figure 1 and Figure A1 in the Appendix), with an average unit price (per square meter) equal to €2,153.6 (Figure 2, and Figure A2 in the Appendix). Focusing on the distribution of the EPC in the full sample, it should be noted that almost a quarter (24.1%) of the listed property presents the highest level of EPC A, while the dwellings with the EPC labels B and C cover a small share of the market (2.4% and 3.1%, respectively). However, most of the dwellings (27.4%) are in the lowest energy category, G, and about a third of the sample is represented by classes E and F (13.4% and 19.9%, respectively). The spatial distribution of the data is presented in Figure 3.

The distribution of listings across energy labels appears to be consistent with the data from the official EPC register for the city of Padua (Regione del Veneto, 2025) considering residential buildings (Table A1). Each year, the register includes EPCs related to properties involved in various types of real estate operations: not only property sales, but also new rental contracts, new constructions, and major renovations. Furthermore, the EPC register includes a broader range of properties compared to our dataset: not only those actively for sale, and it aggregates all different types of residential buildings (apartments, detached houses, etc), while in our dataset we only consider residential apartments for sale. Notably, the representation of high-performing dwellings is greater in our dataset, where these classes account for an average of 24.1% (about 14% in the registered EPCs) in the full sample, while the lower-class F is underrepresented (19.9% vs 26%). This discrepancy is likely due that more energy efficient properties are overrepresented in real estate listings, which tend to reflect more dynamic segments of the market. The under-representation of class F and over-representation of class G might be because when an EPC is missing, agents can still advertise the apartment but are required to obtain the EPC within one month, and have to insert in the listing the lowest energy class G.

3.2 The Hedonic Pricing Model

While other approaches could have been considered to accomplish the objective of our study, we decided to rely on the HPM approach. Typically, HPMs are estimated using linear or semi-logarithmic models. Specifically, we investigated the impact of different characteristics on dwelling price formation ceteris paribus. In this context, the HPM approach offers clear advantages over, for

Table 1. Continuous variables summary statistics.

Variable	n	Min	q_1	Median	Mean	q_3	Max	SD	Missing
Full sample									
Listing Price (€)	1,738	15,000.0	160,000.0	258,000.0	277,558.7	355,000.0	980,000.0	152,941.1	0
Listing Price (€/m^2)	1,738	281.2	1,466.7	2,037.7	2,153.6	2,706.0	6,756.8	909.1	0
Surface (m^2)	1,738	30.0	95.0	124.0	132.9	160.0	470.0	58.4	0
Bathrooms	1,738	1.0	1.0	2.0	1.9	2.0	4.0	0.7	0
Year = 2022									
Listing Price (€)	705	59,000.0	150,000.0	249,000.0	269,393.3	325,000.0	980,000.0	150,599.6	0
Listing Price (€/m^2)	705	613.6	1,486.5	2,000.0	2,136.8	2,615.4	6,217.9	877.6	0
Surface (m^2)	705	30.0	95.0	122.0	130.6	155.0	445.0	56.7	0
Bathrooms	705	1.0	1.0	2.0	1.9	2.0	4.0	0.7	0
Year = 2023									
Listing Price (€)	1,033	15,000.0	165,000.0	260,000.0	283,131.5	368,000.0	950,000.0	154,343.3	0
Listing Price (€/m^2)	1,033	281.2	1,454.5	2,063.5	2,165.0	2,743.4	6,756.8	930.2	0
Surface (m^2)	1,033	30.0	96.0	125.0	134.5	160.0	470.0	59.6	0
Bathrooms	1,033	1.0	1.0	2.0	1.8	2.0	4.0	0.7	0

Table 2. Discrete variables summary statistics.

Variable	Levels	Full sample			year=2022			year=2023		
		n	%	å%	n	%	å%	n	%	å%
Zone	Camin, Zona Industriale	45	2.6	2.6	11	1.6	1.6	34	3.3	3.3
	Forcellini, San Camillo, Nazareth, Terranegra	145	8.3	10.9	66	9.4	10.9	79	7.7	10.9
	Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	221	12.7	23.6	98	13.9	24.8	123	11.9	22.9
	Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	76	4.4	28.0	33	4.7	29.5	43	4.2	27.0
	Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	390	22.4	50.5	149	21.1	50.6	241	23.3	50.3
	Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	278	16.0	66.5	135	19.1	69.8	143	13.8	64.2
	Sacro Cuore, Altichiero	106	6.1	72.6	41	5.8	75.6	65	6.3	70.5
	Scrovegni, Portello, Ospedali, Stanga, Pio X	160	9.2	81.8	57	8.1	83.7	103	10.0	80.4
	Specola, Riviere, San Giuseppe, San Giovanni	144	8.3	90.1	43	6.1	89.8	101	9.8	90.2
	Torre, Mortise, Ponte di Brenta	173	9.9	100.0	72	10.2	100.0	101	9.8	100.0
	all	1,738	100.0		705	100.0		1,033	100.0	
Elevator	0 (absent)	791	45.5	45.5	307	43.5	43.5	484	46.9	46.9
	1 (present)	947	54.5	100.0	398	56.5	100.0	549	53.1	100.0
	all	1,738	100.0		705	100.0		1,033	100.0	
Alarm	0 (absent)	1416	81.5	81.5	562	79.7	79.7	854	82.7	82.7
	1 (present)	322	18.5	100.0	143	20.3	100.0	179	17.3	100.0
	all	1,738	100.0		705	100.0		1,033	100.0	
Energy label	>=A	418	24.1	24.1	159	22.6	22.6	259	25.1	25.1
	B	42	2.4	26.5	24	3.4	25.9	18	1.7	26.8
	C	54	3.1	29.6	29	4.1	30.1	25	2.4	29.2
	D	169	9.7	39.3	58	8.2	38.3	111	10.8	40.0
	E	233	13.4	52.7	106	15.0	53.3	127	12.3	52.3
	F	345	19.9	72.6	120	17.0	70.3	225	21.8	74.0
	G	477	27.4	100.0	209	29.6	100.0	268	25.9	100.0
	all	1,738	100.0		705	100.0		1,033	100.0	

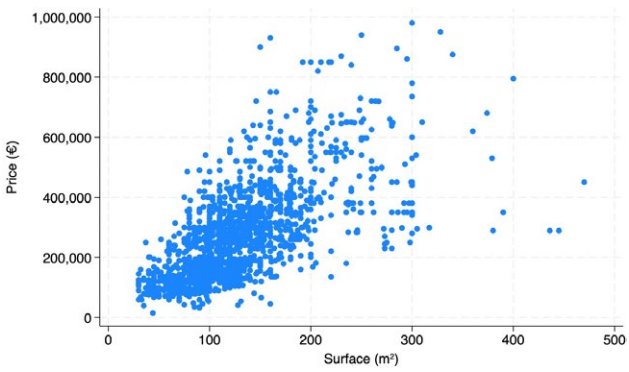

Figure 1. Sample distribution by Price and Surface (Full sample, N = 1,738 records).

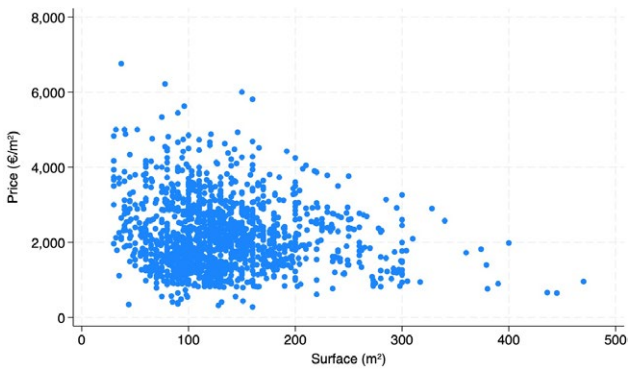

Figure 2. Sample distribution by Unit Price and Surface (Full sample, N = 1,738 records).

example, machine learning approaches (e.g., Neural Networks or Random Forests), particularly when the focus is on the interpretability of coefficients to quantify the specific economic value added by structural or locational attributes. When the focus is on prediction accuracy, machine learning models may offer marginally supe-

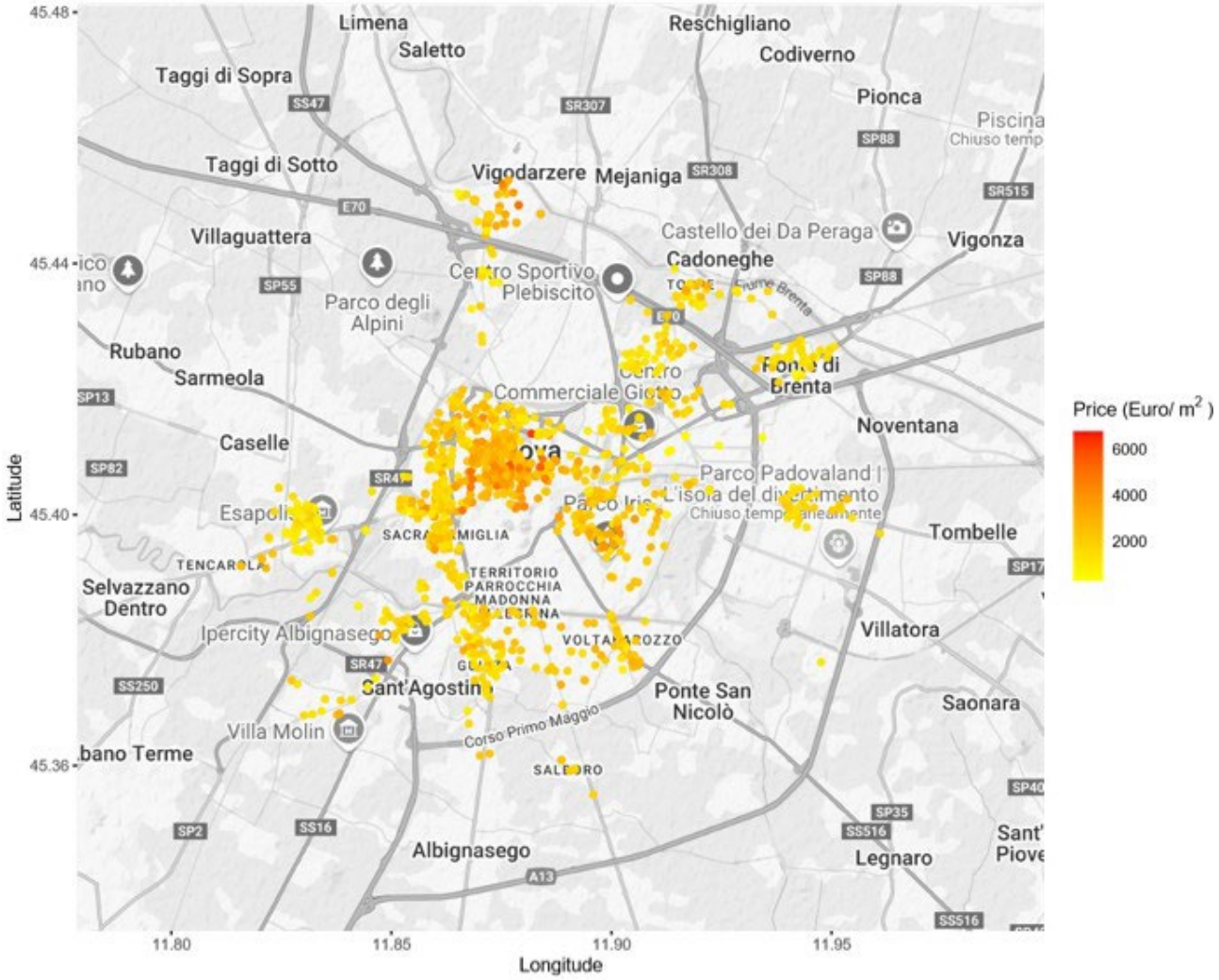

Figure 3. The spatial distribution of the collected data by latitude and longitude in the city of Padua in relation with the price per square meter.

rior performance, but they often lack the transparency required to isolate the ceteris paribus effect of individual independent variables.

The HPM approach, made popular in the early 1960s through applications of Griliches (1958), is founded on the principles of '*Lancaster's Consumer Theory*' (Lancaster, 1966) and theoretical insights from Rosen (1974). According to Lancaster, the utility a consumer derives from a good depends on its characteristics, making it possible to hypothesize that the value a consumer associates with a good depends on its characteristics. In this context, when HPM is applied to real estate, it derives the marginal price of each characteristic of a good, establishing the following functional form within a regression equation:

$$P = f(X_i, Y_i) \tag{1}$$

where P, the listing price of the real estate good, is a function of its intrinsic characteristics X_i and its extrinsic characteristics Y_j.

In more detail, the marginal value of a property's characteristic can be estimated using the following regression equation, which assumes an additive and linear relationship between the price and the good's characteristics:

$$P = K + \sum \beta_i \cdot X_i + \sum \beta_j \cdot Y_j + \epsilon \tag{2}$$

where K is a constant term (intercept), and βs represent the coefficients estimated by the regression equation, which correspond to the marginal values of the characteristics of the good in economic terms, and ε represents the stochastic error.

When Eq. 2 assumes the dependent variable P as logarithmic, the β-coefficients can be interpreted as the percentage change in the value of P for a unit change in the independent variable. More properly, as described by Halvorsen and Palmquist (1980), the estimated coefficients can be interpreted as the percentage variation of the dependent variable (Y) due to a marginal change in categorical or dummy variables. This interpretation holds accurately for small coefficient values (up to about 0.25, namely 25%); while for larger values, the percentage should be computed as:

$$\frac{\Delta Y}{Y} \cdot 100 = (exp(\beta_i) - 1) \cdot 100 \quad (3)$$

If we assume the dependent variable P as logarithmic, Eq. 2 therefore becomes:

$$ln(P) = K + \sum \beta_i \cdot X_i + \sum \beta_j \cdot Y_j + \epsilon \quad (4)$$

We used the standardised dependent variable listing price per square meter (P/m^2), and therefore Eq. 2 becomes:

$$ln\left(P/m^2\right) = K + \sum \beta_i \cdot X_i + \sum \beta_j \cdot Y_j + \epsilon \quad (5)$$

In our analysis, we modelled the relationship between the listing price of apartments and their characteristics as specified in Eq.5, and we estimated the hedonic model considering the following characteristics :

1. the marketable surface of the apartment (m^2)
2. the EPC class
3. the number of toilets/bathrooms in the apartment
4. the presence or absence of an elevator
5. the presence or absence of an alarm system
6. the city zone where the apartment is located.

Other variables were considered in the analysis but were ultimately excluded from the final model due to their lack of statistical significance. For example, the "status" of the dwelling was not considered for two reasons: first, because, at least in Italy, this variable cannot be deduced from the purchase contract, and therefore this characteristic is not observable in the appraisal profession without an in-person and in-situ inspection of each comparable (in other words, to ensure the realism of the valuation, given that for professional purposes real transactions, rather than listing prices should be used); second, because it exhibits a high degree of collinearity with the EPC variable.

Considering our specification of the hedonic model, it should be clarified that dummy or factor variables were used in Eq. 4 to model all categorical variables, namely, all variables except the surface of the dwelling and the number of bathrooms.

4. RESULTS

Considering the first objective of the study, the hedonic regression method was used to investigate whether the EPC of the buildings affects their advertised price. The results of the estimated models are reported in Table 3 (the same results considering EPC class D as reference rather than G are reported in Table A3 in the Appendix for comparison purposes with other studies), while the estimated percentage changes estimated applying equation (3), according to Halvorsen and Palmquist (1980), are reported in Table 4. In addition, Figure 4 displays the coefficients estimated in Table 3. Models' performance (Table 3) was assessed using standard goodness-of-fit indicators. The models explain a substantial share of the variance in the dependent variable (R^2 ranging from 0.529 to 0.622; Adjusted R^2 between 0.521 and 0.612). While these values indicate a moderate goodness-of-fit, they are consistent with standard empirical findings in hedonic price analyses utilizing cross-sectional data. The unexplained variance is largely attributable to unobserved heterogeneity inherent to the real estate market (e.g., interior condition, architectural style, or seller motivation), which cannot be fully captured by structural variables. Crucially, the statistical significance of nearly all independent variables confirms the robustness of the model specification. This indicates that, despite the unobserved heterogeneity reflected in the R^2, the identified structural and locational drivers are reliable and precise determinants of value. Furthermore, we performed a Variance Inflation Factor (VIF) analysis on the full sample model presented in Tables 3 to assess multicollinearity among the independent variables. The mean VIF is 1.66 (see Table A2 in the Appendix), with all individual values falling well below the critical threshold of 5. This indicates that multicollinearity does not affect the stability or significance of the estimates, confirming the robustness of our HPM specification.

The results underscore the significance of the conventional factors typically considered in HPM real estate applications. Almost all independent variables included in the model exhibit a statistically significant relationship with the dependent variable, namely the dwelling price, expressed as $ln(P/m^2)$. Focusing on the full sample, the influence of the EPC is statistically significant for all levels. In particular, the results demonstrated that the higher the EPC level, the higher the asking

Table 3. The hedonic models results.

	Dependent variable: ln(P/m^2)		
	Full sample	year=2022	year=2023
Constant	7.126***	7.185***	7.102***
	[7.063, 7.189]	[7.100, 7.271]	[7.013, 7.191]
Surface (m^2)	-0.003***	-0.003***	-0.003***
	[-0.003, -0.003]	[-0.003, -0.002]	[-0.004, -0.003]
Bathrooms	0.149***	0.091***	0.170***
	[0.118, 0.179]	[0.047, 0.136]	[0.129, 0.212]
Zone: Camin, Zona Industriale	0.082	0.060	0.091
	[-0.017, 0.181]	[-0.102, 0.223]	[-0.036, 0.218]
Zone: Forcellini, San Camillo, Nazareth, Terranegra	0.417***	0.400***	0.441***
	[0.350, 0.484]	[0.314, 0.485]	[0.342, 0.540]
Zone: Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	0.195***	0.181***	0.209***
	[0.134, 0.255]	[0.102, 0.260]	[0.123, 0.296]
Zone: Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	0.402***	0.383***	0.423***
	[0.319, 0.485]	[0.275, 0.490]	[0.303, 0.543]
Zone: Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	0.778***	0.806***	0.764***
	[0.721, 0.835]	[0.731, 0.882]	[0.683, 0.845]
Zone: Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	0.174***	0.175***	0.166***
	[0.116, 0.232]	[0.101, 0.250]	[0.082, 0.251]
Zone: Sacro Cuore, Altichiero	0.199***	0.161***	0.234***
	[0.124, 0.274]	[0.061, 0.260]	[0.128, 0.340]
Zone: Scrovegni, Portello, Ospedali, Stanga, Pio X	0.118***	0.253***	0.055
	[0.052, 0.184]	[0.162, 0.344]	[-0.036, 0.146]
Zone: Specola, Riviere, San Giuseppe, San Giovanni	0.442***	0.408***	0.459***
	[0.374, 0.511]	[0.308, 0.508]	[0.367, 0.551]
Zone: Torre, Mortise, Ponte di Brenta	reference		
EPC: >=A	0.506***	0.473***	0.517***
	[0.459, 0.553]	[0.410, 0.536]	[0.449, 0.585]
EPC: B	0.361***	0.312***	0.361***
	[0.265, 0.458]	[0.202, 0.421]	[0.200, 0.522]
EPC: C	0.253***	0.183***	0.321***
	[0.167, 0.339]	[0.080, 0.287]	[0.185, 0.457]
EPC: D	0.245***	0.165***	0.279***
	[0.192, 0.299]	[0.089, 0.241]	[0.205, 0.352]
EPC: E	0.091***	0.077**	0.095***
	[0.043, 0.139]	[0.016, 0.139]	[0.025, 0.166]
EPC: F	0.071***	0.026	0.097***
	[0.029, 0.113]	[-0.032, 0.084]	[0.039, 0.155]
EPC: G	reference		
Elevator (present)	0.103***	0.093***	0.093***
	[0.070, 0.135]	[0.049, 0.136]	[0.047, 0.139]
Alarm System (present)	0.033*	0.087***	0.005
	[-0.005, 0.070]	[0.037, 0.138]	[-0.049, 0.059]
Observations	1,738	705	1,033
R^2	0.550	0.622	0.529
Adjusted R^2	0.545	0.612	0.521
AIC	758.055	84.128	622.167
BIC	867.265	175.292	720.972

Note: 95% confidence intervals in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

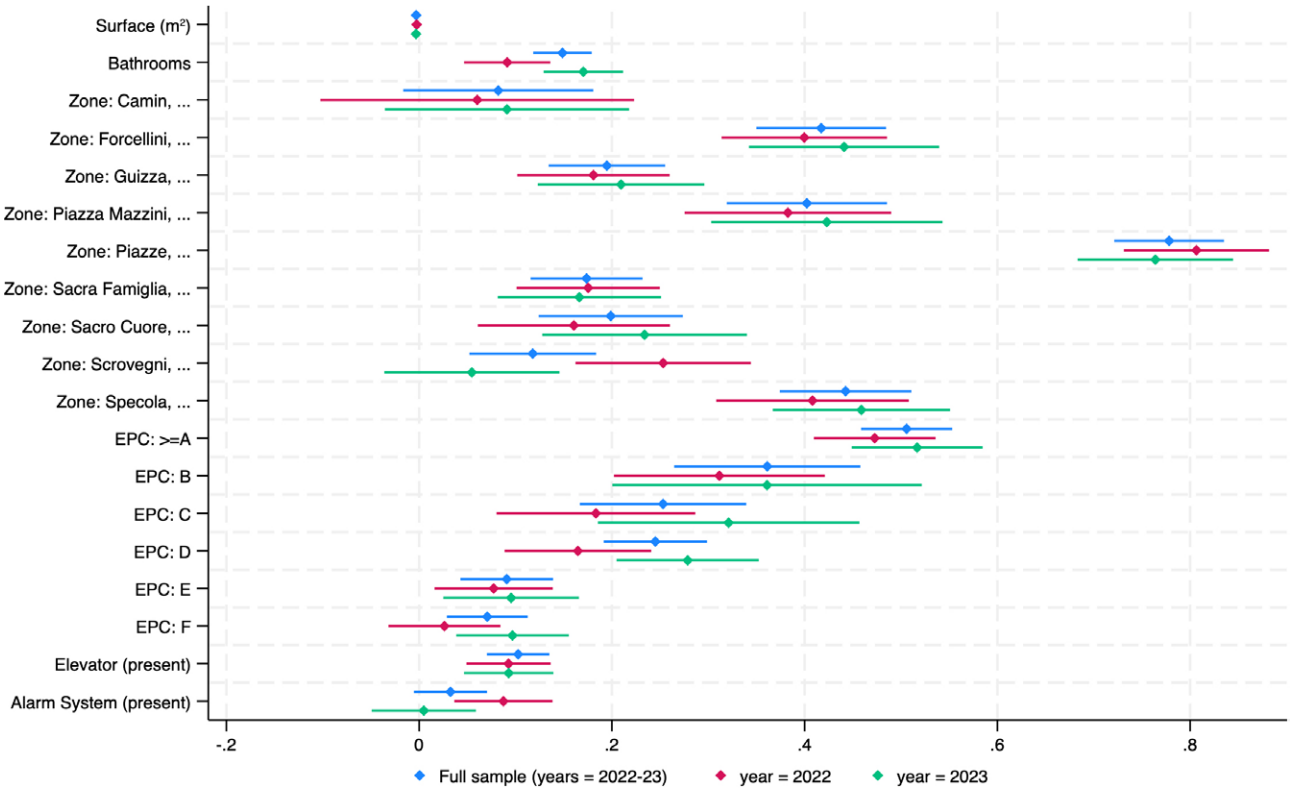

Figure 4. Plot of the coefficients estimated in Table 3. Note: the constant term was omitted because it was out of scale compared to the other coefficients. The dependent variable is the dwelling price, expressed as $ln(P/m^2)$.

price. A dwelling of EPC class >= *A* is worth, on average, 65.8% more than a similar counterpart in class G, while a dwelling with a B label presents a price premium of 43.5%. The influence of the EPC C, D, and E labels is lower, with a price premium of 28.8%, 27.8%, and 9.5%, respectively, compared to the G label. Class F has the lowest effect on the dwellings, with a price premium of 7.3%. The surface of the dwelling (in m^2) presented a negative coefficient: this was expected and consistent with theory given that the dependent variable in our model is the price per square meter and it usually decreases with the dwelling size. The higher the number of bathrooms, the higher the impact on real estate prices. Each additional bathroom increases the premium price by 14.9%. In the same direction, the presence of an elevator and an alarm system command a price premium of 10.8% and 3.3%, respectively. All the zone estimations are positive and statistically significant, except for "Camin, Zona Industriale", which is not statistically significant. Since the zone of reference in our model (zone: "Torre, Mortise, Ponte di Brenta") was an industrial area located in the north-east part of the city, results suggested that areas closer to the city centre present a positive effect on the price given factors such as accessibility and prestige. The price ranges from 12.5% of the zone "Scrovegni, Portello, Ospedali, Stanga, Pio X" to 117.7% of the zone "Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Molino", which is the most central, historical and attractive district of the city.

Regarding the second objective, namely to study the stability of the EPC effect in the short run, we adopted a sequential approach. First, we draw some general considerations investigating the results of the single models of the two years considered (Table 3); second, we did a more detailed investigation to check if the results of the two years could be considered statistically different (Table 5). In the second model (Table 5) all variables (apart from the surface) have been interacted with a dummy indicating if the data were collected in 2023, keeping 2022 as the base level. Considering the results of the single models (general approach), from Table 3 it is possible to observe that some differences, despite being of small magnitude, between the two years considered emerge. More specifically, all EPC classes have a greater influence on dwelling prices in 2023 compared to 2022. A similar result can be observed for the number of bathrooms, and in 5 cases out of 8 if we look at the urban zone. The impact on price of the presence of an elevator

Table 4. Estimated percentage change based on the results of the hedonic models presented in Table 3.

	Dependent variable: ln(P/m²)		
	% change†		
	(Full sample)	(year=2022)	(year=2023)
Surface (m^2)	−0.309	−0.257	−0.325
Bathrooms	14.871	9.137	17.039
Zone: Camin, Zona Industriale	-	-	-
Zone: Forcellini, San Camillo, Nazareth, Terranegra	51.769	49.123	55.413
Zone: Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	21.506	19.821	23.303
Zone: Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	49.524	46.613	52.657
Zone: Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	117.745	124.002	114.665
Zone: Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	18.970	19.172	18.085
Zone: Sacro Cuore, Altichiero	21.994	17.417	26.349
Zone: Scrovegni, Portello, Ospedali, Stanga, Pio X	12.514	28.815	-
Zone: Specola, Riviere, San Giuseppe, San Giovanni	55.657	50.403	58.229
Zone: Torre, Mortise, Ponte di Brenta	reference		
EPC: >=A	65.833	60.429	67.656
EPC: B	43.504	36.551	43.475
EPC: C	28.799	20.131	37.865
EPC: D	27.777	17.907	32.130
EPC: E	9.516	8.038	10.013
EPC: F	7.323	-	10.173
EPC: G	reference		
Elevator (present)	10.820	9.721	9.738
Alarm System (present)	3.307	9.139	-

Note: † For categorical and dummy variables, the percentage change was calculated using Eq. 3.
Reference levels and statistically not significant coefficients were omitted.

is nearly unchanged between the timespan considered, while the presence of an alarm system has a positive effect in 2022, and it is not significant in 2023.

Nevertheless, checking if the results of the two years could be considered statistically different (detailed analysis, Table 5), it is possible to notice that the dummy variable *Year=2023* is not significant, indicating that the dwelling price does not depend on the year of the listing prices, and, therefore, that prices are not influenced by market dynamics or inflation between the two years. Looking at the stability of the EPC effect in the short term, from our results, it emerges that such a difference is significant only for some EPC classes. More specifically, there is no statistically significant effect in the most energy efficient classes (>= *A* and B) with respect to G, while for the other classes, apart from class E, the effect is positive and increasing, and it ranges from 8% (class F) to nearly 15% (class C). It is therefore possible to observe that in 3 EPC classes out of 6, namely in 50 % of cases, there is a different effect of EPC between the two years examined. On the contrary, we can observe that all other variables have no significant differences between the two years, apart from the presence of an alarm system (negative effect) and one case out of 9 for what concerns the location of the dwelling.

5. DISCUSSION AND CONCLUSIONS

This study contributes to the growing body of research on the impact of energy performance certificates on residential property prices, with a specific focus on the city of Padua, Italy. Our results confirm the trend found by previous authors, where the premium price increases passing from lower energy classes to the best performing EPC class, confirming the findings of other studies conducted on the impact of EPC on residential properties in Padua by Copiello and Bonifaci (2015), Copiello and Donati (2021) and Copiello and Coletto (2023). More in detail, from our results the price for an apartment presenting EPC class >= A is 65.8% higher compared to the worst-performing apartments (belonging to class G). In comparison with the findings reported for the city of Padua, this out-

Table 5. The hedonic models results to check if the year affects the estimated coefficients.

	Dependent variable: ln(P/m²)	
	β	95% Conf. Int.
Constant	7.192***	[7.091, 7.292]
Surface (m2)	-0.003***	[-0.003, -0.003]
Bathrooms	0.122***	[0.081, 0.163]
Year = 2023	-0.096	[-0.225, 0.032]
2023 × Bathrooms	0.036	[-0.010, 0.082]
Zone		
Camin, Zona Industriale	0.056	[-0.135, 0.247]
Forcellini, San Camillo, Nazareth, Terranegra	0.403***	[0.302, 0.503]
Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	0.180***	[0.087, 0.272]
Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	0.390***	[0.265, 0.516]
Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	0.808***	[0.720, 0.897]
Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	0.179***	[0.092, 0.266]
Sacro Cuore, Altichiero	0.160***	[0.043, 0.277]
Scrovegni, Portello, Ospedali, Stanga, Pio X	0.254***	[0.148, 0.361]
Specola, Riviere, San Giuseppe, San Giovanni	0.407***	[0.290, 0.525]
Torre, Mortise, Ponte di Brenta	reference	
Camin, Zona Industriale × 2023	0.035	[-0.188, 0.259]
Forcellini, San Camillo, Nazareth, Terranegra × 2023	0.036	[-0.100, 0.171]
Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro × 2023	0.031	[-0.091, 0.153]
Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione × 2023	0.032	[-0.135, 0.199]
Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino × 2023	-0.050	[-0.165, 0.066]
Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria × 2023	-0.017	[-0.133, 0.100]
Sacro Cuore, Altichiero × 2023	0.077	[-0.076, 0.229]
Scrovegni, Portello, Ospedali, Stanga, Pio X × 2023	-0.198***	[-0.334, -0.063]
Specola, Riviere, San Giuseppe, San Giovanni × 2023	0.051	[-0.094, 0.195]
EPC		
>=A	0.466***	[0.392, 0.540]
B	0.311***	[0.182, 0.439]
C	0.180***	[0.059, 0.301]
D	0.157***	[0.068, 0.246]
E	0.070*	[-0.002, 0.141]
F	0.022	[-0.046, 0.090]
G	reference	
>=A × 2023	0.053	[-0.044, 0.149]
B × 2023	0.051	[-0.144, 0.247]
C × 2023	0.147*	[-0.027, 0.320]
D × 2023	0.124**	[0.012, 0.235]
E × 2023	0.029	[-0.067, 0.125]
F × 2023	0.076*	[-0.011, 0.162]
Elevator (present)	0.093***	[0.042, 0.144]
2023 × Elevator (present)	0.001	[-0.066, 0.068]
Alarm System (present)	0.089***	[0.029, 0.149]
2023 × Alarm System (present)	-0.087**	[-0.165, -0.010]
Observations	1,738	
R^2	0.560	
Adjusted R^2	0.550	
AIC	758.230	
BIC	971.190	

Note: 95% confidence intervals in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

come is higher than that of 21.9% detected by Copiello and Bonifaci (2015), but it is consistent with the 61.7% highlighted by Copiello and Donati (2021) and with the band found by Copiello and Coletto (2023). Even if these studies have the same urban area in common with our application, a direct comparison of the results is not straightforward due to some differences. Even if all these studies used as data listing prices, the timing of data collection and the sample size were not the same. Moreover, we have to consider the different analytical approaches implemented and the independent variables included in the models. For example, Copiello and Bonifaci (2015) focused on residential buildings using listing prices collected from April to July 2013, namely around ten years before our application. Such a time gap might be one of the causes of the discrepancy of our results with those of the authors, since the impact of the EPC might have changed as a result of numerous dynamics over nearly a decade. Such a hypothesis is supported by Barreca et al. (2021), who found that, contrary to empirical evidence, in the first years after the implementation of EPC in Italy, these labels are increasingly exerting a significant influence on price variations. If the data of Copiello and Donati (2021) refer to around a few years before our study (third quarter of 2019), the authors analysed the data with a spatial dynamic model. Findings of Copiello and Coletto (2023) are referred to 2022 but are limited to a specific period of the year (March-July), so including 321 observations. Moreover, the different analytical approaches implemented and the independent variables included in the models make it challenging to compare the results across studies. Lastly, it should be noted that we have adjusted our estimates as suggested by Halvorsen and Palmquist (1980) for discrete variables (see Eq. 3), and therefore the magnitude of the estimates, when greater than 25%, could be even greater in the case where estimates were not adjusted. Our findings showed that while for other characteristics results could be considered quite stable in the short run, for the EPC classes there seems to be a greater effect with time, an effect that proved significant for lower energy classes. Such a result, despite needing further validation, is quite interesting and could be explained with some considerations. First, it might well be that, as highlighted by Olaussen et al. (2017), the EPC, being potentially highly correlated with other characteristics of the building or dwelling, captures, along with the premium price for energy efficiency, other aspects related to the dwelling, like for example its maintenance status or whether it was recently renovated. In this respect, it is possible that old dwellings with low EPC classes were partially renovated, with an improvement of the EPC class. Partial renovation could improve the EPC but not bring it to the highest levels, which could be an explanation for the difference between the two years found to be significant only for lower EPC classes, rewarding the niche market of partially renovated dwellings.

The observed price premiums associated with higher EPC ratings could serve as an incentive for homeowners to invest in energy-efficient upgrades and renovations. Beyond the potential for reducing energy costs and enhancing environmental sustainability, our findings suggest that such investments may also translate into tangible increases in property values. This dual benefit could motivate homeowners to prioritize energy efficiency measures, contributing to the EU's overall goal of decarbonizing the building stock.

Our study suggests some lines for future research. First, our results should be validated given that they could be 'context-dependent' both in space and time, and therefore similar studies would be necessary to validate our results considering different cities in different periods. A further aspect that deserves attention is the understanding of the reliability of the use of listing prices in the appraisal practice, especially when using results in absolute values rather than relative percentages. In this respect, it would be interesting to scientifically estimate the average discrepancy of listing prices from real transaction prices. For now, it is possible to affirm that the relative percentages of the premium prices derived in listing price studies could be used, subject to further validation, in classical appraisal approaches like, for example, the Market Comparison Approach. Such analytical effort would be particularly relevant given that the use of Big Data collected with the web crawling technique resulted particularly effective and therefore allows to overcome the difficulty of operating with real transaction data, especially in the Italian or similar context, where data are available, but of difficult accessibility. Furthermore, Italian data need to be carefully studied, given that they depend on the data reported in transaction documents (they are not readily available in a 'database' form), which do not follow a standard format, and often miss some important information like the status of the dwelling, while for example the EPC is nowadays always reported given that it is compulsory by law.

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APPENDIX. ADDITIONAL STATISTICS AND FIGURES

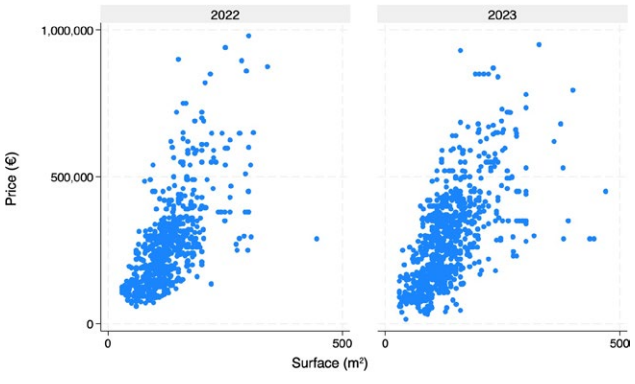

Figure A1. Sample distribution by Price and Surface by year.

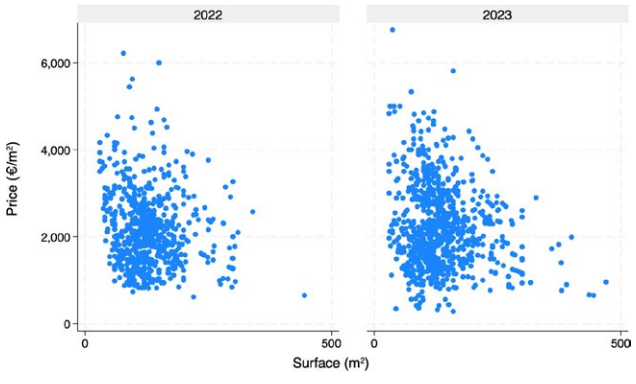

Figure A2. Sample distribution by Unit Price and Surface by year.

Table A1. EPC classes comparisons between the study sample and Padua Municipality residential statistics of registered EPCs. Own elaboration based on data available on Regione del Veneto (2025).

Energy label	Full sample		Study Sample				Municipal Registered EPCs *			
			year=2022		year=2023		year=2022		year=2023	
	n	%	n	%	n	%	n	%	n	%
>=A	418	24.1	159	22.6	259	25.1	649	13.3	924	14.8
B	42	2.4	24	3.4	18	1.7	129	2.6	221	3.5
C	54	3.1	29	4.1	25	2.4	220	4.5	381	6.1
D	169	9.7	58	8.2	111	10.8	494	10.1	699	11.2
E	233	13.4	106	15	127	12.3	799	16.4	1,085	17.3
F	345	19.9	120	17	225	21.8	1,330	27.3	1,542	24.6
G	477	27.4	209	29.6	268	25.9	1,247	25.6	1,407	22.5
all	1,738	100.0	705	100.0	1,033	100.0	4,868	100.0	6,259	100.0

Note: * data refer to the registered EPCs in the municipality of Padua for residential buildings (Regione del Veneto, 2025) of all types (apartments, detached houses, etc.). The considered municipality data included all registered EPCs, not only those for buildings on sale, while the study sample considered only residential buildings in the apartments category for sale.

Table A2. Variance Inflation Factor (VIF) analysis related to the Full sample model reported in Table 3.

Variable	VIF	1/VIF
Surface (m^2)	1.94	0.515517
Bathrooms	2.01	0.498356
Zone:		
Camin, Zona Industriale	1.24	0.808198
Forcellini, San Camillo, Nazareth, Terranegra	1.75	0.572506
Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	2.05	0.48838
Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	1.46	0.686173
Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	2.84	0.351695
Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	2.29	0.437268
Sacro Cuore, Altichiero	1.62	0.618551
Scrovegni, Portello, Ospedali, Stanga, Pio X	1.82	0.548833
Specola, Riviere, San Giuseppe, San Giovanni	1.79	0.559873
EPC:		
>=A	2.06	0.486187
B	1.11	0.9012
C	1.13	0.88326
D	1.27	0.786563
E	1.35	0.738194
F	1.41	0.707525
Elevator (present)	1.31	0.760979
Alarm System (present)	1.1	0.912921
Mean VIF	1.66	

Table A3. The hedonic models result considering the EPC level D as reference level.

	Dependent variable: ln(P/m²)		
	Full sample	year=2022	year=2023
Constant	7.371***	7.350***	7.380***
	[7.296, 7.446]	[7.247, 7.453]	[7.277, 7.484]
Surface (m^2)	-0.003***	-0.003***	-0.003***
	[-0.003, -0.003]	[-0.003, -0.002]	[-0.004, -0.003]
Bathrooms	0.149***	0.091***	0.170***
	[0.118, 0.179]	[0.047, 0.136]	[0.129, 0.212]
Zone: Camin, Zona Industriale	0.082	0.060	0.091
	[-0.017, 0.181]	[-0.102, 0.223]	[-0.036, 0.218]
Zone: Forcellini, San Camillo, Nazareth, Terranegra	0.417***	0.400***	0.441***
	[0.350, 0.484]	[0.314, 0.485]	[0.342, 0.540]
Zone: Guizza, Crocifisso, Ponte Quattro Martiri, Voltabarozzo, Salboro	0.195***	0.181***	0.209***
	[0.134, 0.255]	[0.102, 0.260]	[0.123, 0.296]
Zone: Piazza Mazzini, Ospedale Militare, Porta Trento, Stazione	0.402***	0.383***	0.423***
	[0.319, 0.485]	[0.275, 0.490]	[0.303, 0.543]
Zone: Piazze, Duomo, Santo, Santa Sofia, Altinate, Savonarola, Ponte Molino	0.778***	0.806***	0.764***
	[0.721, 0.835]	[0.731, 0.882]	[0.683, 0.845]
Zone: Sacra Famiglia, Basso Isonzo, Brusegana, Aeroporto, Paltana, Mandria	0.174***	0.175***	0.166***
	[0.116, 0.232]	[0.101, 0.250]	[0.082, 0.251]
Zone: Sacro Cuore, Altichiero	0.199***	0.161***	0.234***
	[0.124, 0.274]	[0.061, 0.260]	[0.128, 0.340]
Zone: Scrovegni, Portello, Ospedali, Stanga, Pio X	0.118***	0.253***	0.055
	[0.052, 0.184]	[0.162, 0.344]	[-0.036, 0.146]
Zone: Specola, Riviere, San Giuseppe, San Giovanni	0.442***	0.408***	0.459***
	[0.374, 0.511]	[0.308, 0.508]	[0.367, 0.551]
Zone: Torre, Mortise, Ponte di Brenta	reference		
EPC: >=A	0.261***	0.308***	0.238***
	[0.203, 0.319]	[0.226, 0.390]	[0.159, 0.317]
EPC: B	0.116**	0.147**	0.082
	[0.013, 0.219]	[0.024, 0.269]	[-0.083, 0.248]
EPC: C	0.008	0.019	0.042
	[-0.085, 0.101]	[-0.097, 0.134]	[-0.100, 0.185]
EPC: D	Reference		
EPC: E	-0.154***	-0.087**	-0.183***
	[-0.214, -0.094]	[-0.170, -0.005]	[-0.267, -0.100]
EPC: F	-0.174***	-0.138***	-0.182***
	[-0.230, -0.119]	[-0.219, -0.058]	[-0.256, -0.107]
EPC: G	-0.245***	-0.165***	-0.279***
	[-0.299, -0.192]	[-0.241, -0.089]	[-0.352, -0.205]
Elevator (present)	0.103***	0.093***	0.093***
	[0.070, 0.135]	[0.049, 0.136]	[0.047, 0.139]
Alarm System (present)	0.033*	0.087***	0.005
	[-0.005, 0.070]	[0.037, 0.138]	[-0.049, 0.059]
Observations	1738	705	1033
Adjusted R^2	0.545	0.612	0.521
AIC	758.055	84.128	622.167
BIC	867.265	175.292	720.972

Note: 95% confidence intervals in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Firenze University Press
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OPEN ACCESS

Citation: Locurcio, M., Morano, P., Amoruso, P., Di Liddo, F. & Tajani, F. (2026). From surface right to full ownership: three approaches to determine the fair fee. *Aestimum* 88: 71-86. doi: 10.36253/aestim-18916

Received: October 22, 2025

Accepted: December 17, 2025

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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From surface right to full ownership: three approaches to determine the fair fee

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Abstract. The topic of public residential housing is relevant in the international context with different peculiarities and approaches in the various European Member States, according to the several political, economic, and cultural specificities, despite some general analogies characterizing this sector. The present research focuses on the Italian territory, aiming to critically analyse the institute mostly implemented in the initiatives of social housing, that is the surface right. In particular, the objective of the study is to empirically verify the fair fee to be paid for the conversion of surface right into full ownership, overcoming the legal provisions and considering also the real estate market and the compensation approach which takes into account the initial advantage of the assignees. By applying the three approaches, the potential disparities caused by the current legislation are highlighted and the possible increased revenues for the Public Administration generated if the normative forecasting were integrated by including real estate factors, are detected.

Keywords: surface right, social housing, conversion value, full ownership, superficiary.

1. INTRODUCTION

Public residential housing, also known as social housing, represents a crucial component of policies adopted by various European countries. The main objective of this sector is to provide affordable residential solutions for low- and middleincome groups, thereby contributing to greater social cohesion and collective well-being. The size of the sector and the methods of its management vary significantly among the different EU Member States. On average, about 20% of European households live in social housing (Housing Europe, 2023); however, the proportion of social housing within the overall

dwellings stock differs considerably across countries. Despite differences linked to the specific national contexts, the social housing sector faces several common challenges, including limited financial resources, issues related to maintenance and management, and a continuously growing demand that exceeds the available supply. In response to these arguments, the European Union promotes policies and financial instruments aimed at strengthening social and affordable housing (European Commission, 2023). A significant initiative in this field is the Affordable Housing Initiative, which guides the New European Bauhaus (NEB). This program integrates environmental sustainability, aesthetic value, and social inclusion, with the aim of supporting the ecological transition in the construction sector more fairly and inclusively (European Union, 2020). Although relevant differences among each Member State rooted in their unique historical, economic, and social backgrounds, it is still possible to identify some common features in the interpretation of social housing. In particular: *i)* the objective is generally recognized as being of public interest, aimed at increasing the availability of affordable housing through construction, management, or acquisition of properties for this purpose; *ii)* the target population is defined based on socio-economic criteria or the presence of vulnerabilities (European Parliament, 2013).

In the Italian national context, over time, the State has played a decisive role in the real estate market, intervening in various ways to ensure access to housing, recognized as a fundamental right by the Constitution. Government housing policies have evolved in response to the different economic and social phases the country has gone through, with the main purpose of countering shelter deprivation and promoting social inclusion through access to housing. After World War II, Italy faced a severe housing shortage, especially in large cities, due to population growth, urbanization, and the abandonment of homes damaged by the conflict. Within this framework, the government intervened with a public residential construction plan aimed at meeting the demand for public housing (Autonomous Institutes for Public Housing – IACP), also through financing programs for building new dwellings intended for the less affluent social classes with rent-controlled leases. Starting from the 1970s, with rising property prices and increasing economic inequalities, the Italian State has further expanded and integrated its intervention in the housing market. The inclusion of fiscal incentives to encourage homeownership, such as tax deductions on expenses for purchasing and renovating properties, has strongly stimulated demand for private housing. During this period, private residential construction has assumed an increasingly significant function, with the State continuing to be a key player by regulating the sector through laws aimed at protecting tenants' rights and opposing real estate speculation.

More recently, during the 1990s and 2000s, the strategic policies developed by the national government have continued to address housing challenges with measures pursued to support the real estate market, promoting the creation of instruments such as real estate funds, but also encouraging long-term rental policies through the introduction of agreedrent contracts. These agreements have been designed to reduce rental costs for low-income families and stabilize the rental market in a context where demand for rental housing has grown significantly. In parallel, the surface right has been introduced as one of the essential institutes to solve the problem of scarce building land in urban areas, allowing the use of public land without transferring ownership, for affordable residential construction projects benefiting economically disadvantaged families. Moreover, the State has maintained its crucial role in financing and managing social housing policies to promote the inclusion of vulnerable groups such as low-income families, young couples, the elderly, and people with disabilities. The definition of social housing programs through tenders for the construction and renovation of affordable rental housing has aimed to ensure that housing remained accessible to all social classes, even within a context of a growing private market and liberalization of the real estate sector. In the Italian context, for decades, the State has held a dual role, both as legislator and market regulator and as a direct economic actor, through the promotion of public residential construction projects and support for fiscal and financial policies to facilitate the purchase and rental of housing. These interventions have allowed not only to address the housing scarcity but also responding to the country's social, economic, and demographic transformations, aiming for more equitable access to homeownership and the enjoyment of housing.

2. AIM

As clarified above, social housing plays a fundamental role in the international panorama, as it aims to ensure the lowincome population the right to adequate housing. In the context of growing urbanization and rising real estate costs, this model represents a concrete response to the housing crisis, promoting social inclusion and community cohesion. In addition to providing housing at controlled prices, social housing fosters sustainable urban development, reduces inequality, and

contributes to collective well-being. This research first provides an overview of the different approaches used in the management of social housing across various European countries, highlighting the heterogeneity resulting from differing political, economic, and cultural contexts, despite some general analogies characterizing this sector. Subsequently, the study focuses on the evolution of social housing in Italy, with an in-depth examination of the main instrument still used in the development of public housing initiatives in Italian context, namely the surface right.

In particular, the objective of this research is to empirically investigate the approach established by current legislation that allows housing assignees (superficiaries) to convert surface right into full ownership, upon payment of an amount provided by law. The aim is to assess whether the amount obtained through the legally defined formula differs from the amount that would result from *i)* a purely market-based approach, and *ii)* a model based on the legitimate need to compensate the community for the initial advantage granted to the assignees-superficiaries. By applying these three different logics to a case study consisting of various areas distributed throughout Italian territory, the present study intends to highlight any disparities caused by the current legislative model, to the disadvantage of potentially higher revenues that Public Administrations could obtain through the use of the two alternative models proposed by the authors.

The novelty of this research lies in proposing a methodological approach that goes beyond purely market-based logic addressed in the existing literature, also taking into account the initial advantage in favour of the beneficiaries, intrinsically linked to the lower price of the dwelling at the time of assignment. This gain is recognized in exchange for compliance with restrictions on the transfer of the properties and represents a key element for a more fair and comprehensive assessment of the processes involved in converting the surface right into full ownership. Thus, incorporating this dimension allows for a more nuanced understanding of the distributional implications of such conversions and helps identify the conditions under which the mechanism can ensure greater equity and long-term sustainability.

The paper is structured as described below: in Section 3 an overview of social housing in EU Member States is provided; in Section 4 the history and framework of public residential housing in Italy is described; in Section 5 the methodological approach based on the three different models (i.e. legal-based approach, market approach and compensation one) is illustrated; in Section 6 the proposed method is applied to the case study related to the Italian territory and obtained results are discussed; in Section 7 the conclusions and future developments of the research are presented.

3. OVERVIEW OF EU MEMBER STATES

Generally, there are some common strategies adopted to address housing challenges: primarily, many European countries allocate public funds for the construction and maintenance of social housing units. For example, the European Union has proposed the establishment of a pan-European investment platform for sustainable, affordable housing, allowing local authorities and cooperatives to obtain long-term, zero-interest loans (European Economic and Social Committee, 2024). Moreover, in several States, cooperatives and non-profit organizations play a key role in managing and developing social housing. These collaborations aim to ensure quality housing at affordable prices while promoting social cohesion. In terms of the size of the sector, social housing represents close to 28 million dwellings and accounts on average for 8% of the total housing stock in the European Union. Representing more than 20% of the overall housing supply, this sector is most prominent in Austria, Denmark, and the Netherlands. Finland, France, Iceland, Ireland, and the United Kingdom have a moderately sized social rental housing sector, comprising between 10% and 19% of the total stock. In contrast, the sector remains relatively limited-ranging from 2% to 10% of the total housing supply-in countries such as Belgium, Czechia, Germany, Hungary, Italy, Norway, Poland, the Slovak Republic, Slovenia and Switzerland.

The smallest share of social housing, making up less than 2% of the total stock, is found in Estonia, Latvia, Lithuania, Portugal, and Spain (OECD, 2024). Despite some general analogies, different approaches can be attributed to four dimensions: *i)* tenure; *ii)* provider of the service; *iii)* beneficiaries; *iv)* funding arrangements. Regarding tenure, social housing is primarily offered for rent in most countries, though the option to purchase dwellings also exists in many cases (e.g. in Italy, Ireland, France, Germany, Finland, Estonia, The Netherlands, Poland, Portugal, Slovenia, Spain). Additionally, some countries provide intermediate tenure solutions, such as shared ownership, where tenants purchase a portion of the property while paying rent on the remaining share (a model that has become increasingly common in the UK). In other countries, including several Mediterranean nations like Cyprus, Greece, and Spain, social housing has been made available as low-cost housing for sale. Social rental housing is available in all Member

States except Greece, whereas home ownership is absent in Northern Europe and much of Eastern Europe (as in Denmark, Sweden, Latvia, and Lithuania). Meanwhile, shared ownership exists in certain countries but does not follow a clear geographical trend (European Parliament, 2013).

Another legal instrument common in some European countries, primarily Italy and France, is based on the principle of separating ownership of the land from that of the building on it. In France, the term "*bail à Construction*" refers to a long-term contract in which the tenant (*locataire*) acquires the right to build on land owned by the landlord, and then operates the building as a residence, often in a social housing context (*habitation à loyer modéré* or *HLM*). This instrument, which differs from a standard rental contract, allows for the construction of social housing, promoting the creation of housing infrastructure for people with low or moderate incomes through a rent-controlled rental system. In Italy, the surface right is used in social housing to separate ownership of the land (often owned by a public entity) from that of the building, enabling the construction and management of affordable housing. Public entities grant building rights for a fixed period, after which ownership of the building can revert to the public entity. This mechanism helps reduce construction costs and make social housing initiatives economically sustainable, offering housing solutions to low-income or disadvantaged segments of the population. With reference to the provider of the service, there are various subjects responsible for developing and managing social rental housing. In several countries, regional and municipal authorities or agencies are responsible for at least half of the social housing sector. In some countries, central government agencies also play a direct role in providing social housing, including Belgium, Denmark, Italy, Luxembourg, Malta, Portugal, Romania and Slovenia. Except for Iceland, countries where public authorities are the sole providers of social rental housing tend to have relatively small social housing sectors, as seen in Hungary, Latvia, Lithuania, Norway, and the Slovak Republic.

Meanwhile, in several countries with a substantial or moderate share of social rental housing, such as the Netherlands and Finland, non-profit or limited-profit housing associations have a significant presence. In England, as well as in Austria, a large non-profit and limited-profit sector operates alongside a considerable stock of housing owned and managed by local authorities. However, in England, local authorities have significantly reduced their investment in constructing new housing units. In France, the HLM (*habitations à loyer modéré*) sector is primarily managed by regional and municipal authorities, along with non-profit providers (OECD, 2024). Considering the growing need to respond to sustainability requirements in the construction sector, social cooperative and public housing providers have to combine availability, affordability and sustainability in planning and implementing their activities. Specifically, social, public, and cooperative housing often show better performance than purely private housing. This demonstrates the crucial role of public, cooperative and social housing in driving a fair energy transition and addressing the cost-of-living crisis that is affecting many families.

Taking France as an example, 46% of the social housing stock qualifies A, B, or C as Energy Performance Label (EPL), compared to only 25% of all homes. The situation reported for Italy presents a significantly less favorable picture: more than half of the available buildings are characterized by EPL equal to F and G, indicating that the level of energy efficiency in residential units in Italy is relatively low. In fact, the Italian property stock is characterized overall by a high elderly, with a greater historicity than other European countries; public rental housing (*Edilizia Residenziale Pubblica*, ERP) is estimated to account for about 3.5% of the country's total real property stock. Therefore, the need to renovate public housing is widespread, taking into account that about 10% of the stock is currently vacant (Housing Europe, 2023). There are also notable geographical differences regarding potential beneficiaries of social housing. In some countries, social or public housing is a universal service available to all citizens, with the public sector mainly acting as a market regulator and promoting social diversity in line with local policies. Conversely, in other nations, social housing is a targeted service operating separately from the private rental market, benefiting only households considered unable to be served. In particular, eligibility criteria are different: in some countries, access is determined on the basis of income thresholds assessed through means-testing, while in others, social housing is specifically intended for the most vulnerable groups. Income ceilings are the most common criteria used to define eligibility for social housing. In countries such as Austria, France, and Germany, the upper income limit is set high enough to ensure a diverse mix of beneficiaries, whereas in others, like Italy, the threshold is much lower.

Additional criteria for housing allocation include household needs, based on observable individual circumstances such as poor housing conditions, homelessness, unhealthy living environments, overcrowding, or involuntary cohabitation. In some cases, priority is given to specific groups, such as young people, the elderly, people with disabilities, large families, individuals with

mental health conditions, ethnic minorities, or refugees. Moreover, in some countries as Denmark, Sweden, and the UK, applications for social housing waiting lists are open to everyone, aiming to prevent social segregation and ensure that public housing remains accessible to all parts of the community. However, in practice, the eligibility for the house is largely based on the actual need, and despite the absence of income limits in some cases, there is still a strong correlation between income levels and access to social housing. Lastly, the funding mechanisms employed to finance social housing take on various forms. In certain countries, the sector is almost entirely supported by public funds, while in others, housing providers rely heavily on credit obtained from the financial markets. Additional differences arise from factors such as the maturity level of social housing providers, government commitment to the sector, and conditions in the mortgage market. Housing projects in nearly all EU Member States are financed through different sources, including bank loans, mortgages, public grants, public loans, private funds from housing organizations, and contributions from tenants.

Furthermore, municipalities can contribute by providing funding or offering land for social housing construction at reduced prices or even for free. In certain countries, such as Austria, Italy, and Luxembourg, other essential factors for social housing provision include the availability of public land at discounted rates or tax deductions and credits for social housing providers. Moreover, the setting of rents plays a crucial role in the financial sustainability of social housing, as the existence of benefits for demand-side support. Given that housing providers fund a significant portion of their operations through loans and mortgages, various public aid schemes have been established. Generally, the public sector supports the housing sector through grants, public loans from specialized public credit institutions, interest rate subsidies, and government-backed guarantees. In some countries, social housing is directly provided by local authorities, and the financial burden may be partially or fully absorbed by the municipal budget through transfers from the national budget. However, the general level of public investment in housing development and in particular affordable housing is considered still low: as highlighted by the OECD, public investment in housing development has halved since 2001, more specifically, during the global financial crisis of 2009 there was a sharp decline in public financial support and in many European countries the level of public spending on housing development is still lower than the 2009 level. Moreover, the current macro-economic situation must be considered, starting from rising inflation, particularly from the sharp increase in construction and renovation costs that began in 2021 as a result of supply chain disruptions due to the Covid 19 pandemic and culminated in late 2022 following the invasion of Ukraine.

The cost-of-living crisis has eroded real incomes and the surge in interest rates has made borrowers more vulnerable to financial distress. In particular, it resulted in an increasing demand in social housing: for instance, the number of households applying for social housing in France has reached 2.4 million, 16% more compared to 2016 and 7% more in just one year since 2021. Households registered to obtain social housing in Brussels have increased from 49,000 in 2020 to almost 52,000 in 2022 – and this list could continue to grow. For this reason, the social housing sector requires adequate funding and policies that are grounded in the local realities. In this regard, the availability of greater economic resources is crucial for financing renovation and construction projects, both in terms of European support policies and programs, as well as national and local strategies, which also facilitate the involvement of private entities and cooperatives.

4. THE EVOLUTION OF THE ITALIAN LEGISLATIVE FRAMEWORK IN SOCIAL HOUSING

The analysis of the broader European framework reveals that social housing has evolved through diverse models shaped by the specific historical, political, and socio-economic peculiarities of each country. Despite this diversity, certain underlying principles remain consistent across national contexts. In Italy, the origin of social housing can be attributed to the Fascist era (1922–1943), during which the State and cooperatives intervened in response to the growing need to improve the housing conditions of low-income categories of population. During the Twenty-year period the social housing became a tool of social control, while in the post-war period, the Insurance National Institute (INI) - Casa Plan marked its greatest expansion, with widespread interventions of relatively high architectural quality. The INI-Casa Plans were public residential construction programs promoted in Italy between 1949 and 1963 by the INI in collaboration with the State. Their main objective was to address the post-war housing emergency and to stimulate employment in the construction sector. With this aim, the government has introduced over time specific housing strategies for providing affordable accommodation for the most vulnerable groups.

A pivotal step in this process has been the creation of the Economic and Popular Housing Plans (PEHP)

with Law No. 167 on April 18, 1962, later amended by Laws No. 904 (July 21, 1965) and No. 865 (October 22, 1971). These Plans have identified designated zones for the development of affordable or public housing, with the necessary infrastructure and collective services, as green areas and communal facilities, according to the urbanistic standards. In this context, the legislation has authorized the expropriation of land for public purposes within these zones, through the inclusion of a compensation mechanism based on the land's value two years before the approval of the PEHP. This form of reduced indemnity - since it did not consider the current market value – has aimed to allow municipalities, public housing institutes (IACP) and social housing operators to access buildable land at lower selling prices. The acquired land was then to be developed according to integrated planning, ensuring the inclusion of essential public services within the same zoning scheme.

Among the legal and regulatory instruments widely used in Italy for public housing initiatives, the surface right has assumed a significant role, as it allows for more flexible and efficient land management-particularly in urban areas where the availability of buildable land is limited. The surface right derives from the Roman law (*superficies*), where it referred to the possibility of building on someone else's land in exchange for a fee. In the Roman system, it was not a fully autonomous right, but rather a concession that resembled a contractual relationship more than a true real right. In postunification Italy, the 1865 Civil Code included the institution only marginally. The 1942 legislator with the Civil Code has strengthened the institution for economic and social reasons, making it a useful tool to support construction activity and manage real-estate assets. Over time, the surface right has progressively evolved into a flexible instrument, capable of adapting to changing housing needs, public–private partnerships, and urban development strategies, thus acquiring renewed relevance in contemporary property law.

Specifically, in public housing policies, the use of surface rights has represented a concrete response to the growing demand for housing, enabling the State to promote the development of construction projects at lower costs without transferring the ownership of public land. In particular, surface right has been introduced by Article 35 of Law No. 865 of October 22, 1971, which has provided two different legal procedures for allocating land within PEHP zones: full ownership transfer, which permanently conveys the land to private subjects, and the granting of surface rights. The latter allows beneficiaries (known as superficiaries or leaseholders) to build and own constructions while public authorities continue to be the owner of the land for a fixed term from 60 to 99 years.

However, surface rights may be established for an indefinite period (named indefinite-term surface right). In this case, the right may be granted for an unlimited time, and the ownership of the land always remains with the grantor. Once the building is completed, these operators transfer the leasehold title (or the surface right) of each housing unit at subsidized prices to eligible individuals, based on predetermined income thresholds. Specifically, the surface right is governed by Articles 952–956 of the Italian Civil Code. Also referred to as superficial ownership, it is a legal mechanism that allows the *superficiary* to construct, own and benefit from a building located on land legally owned by the *landowner* (*the grantor*). This structure legally separates land ownership from building ownership, allowing the *superficiary* (*the grantee*) to use the property for economic or residential purposes without acquiring the underlying land.

Among the various legal procedures to constitute the surface right, the Italian normative establishes the contract – either for a fee or free of charge - for which the compensation, if it is involved - can be paid either as a lump sum or through recurring payments, such as an annual concession fee. Moreover, the will, i.e. via testamentary disposition, and the adverse possession (usucapion), provided that the legal conditions for such acquisition are met, represent alternative modalities included in the legislation to obtain the surface right. A significant development has occurred with Article 31 of Law No. 448 of December 23, 1998, which has granted municipalities the opportunity to convert land initially assigned under surface rights within PEHP areas into full ownership. This allows leaseholders to transform their right into full freehold ownership, purchasing the land on which their properties stand on. This possibility regards both the fixed-term surface right and the indefinite-term one. The conversion process is initiated by the municipality and requires the voluntary agreement of each housing beneficiary, formalized through a notarial deed. The fee to be paid for the acquisition is determined using a standardized formula outlined in Law No. 448/1998.

Although surface right is regulated at the national level by the Civil Code, its practical application varies significantly across municipalities, which adapt it to specific urban, social and economic objectives. The main differences concern the allocation criteria (requirements, procedures and priorities), the duration of the right and renewal conditions, the rents, the urban and building restrictions and the monitoring and sanctions in case of non-compliance. These variations reflect the flexibility of the institute, which municipalities use to pursue territorial policy goals such as managing public assets, urban development, social housing and regulating real estate prices.

Within this framework, it is evident that the State continues to use the surface right as a housing policy institute, in line with its priority to support universal access to housing also in areas characterized by higher selling prices. In this sense, the surface right has, over time, provided a practical solution to the issue of land accessibility in densely populated urban areas, allowing for the use of public land without transferring its ownership. Considering the importance of this institute, on the one hand, the legal and normative aspects of surface right, as well as the procedures for its conversion into full ownership, find consistent foundation in the normative literature (Magri and Scilhanick, 2006). On the other hand, however, the appraisal methodology applied to these real rights does not always adequately reflect actual market conditions (Carbonara and Stefano, 2021; De Mare and Nesticò, 2010), resulting in a discrepancy between the market value and the legal evaluation (Patel and Patel, 2023) which is often based on normative prescriptions detached from market dynamics.

5. METHODOLOGICAL APPROACH

This paragraph describes three different methodological approaches through which it is possible to determine the amount to be paid for the conversion of surface right into full ownership. The first approach (the so-called *legal-based* approach) follows the provisions currently established by Italian law; the second (the so-called *market* approach) is based purely on market logic; the third (the so-called compensation approach) aims to offset the initial advantage granted to the holders of surface right.

5.1 Legal-based approach

The current legislative provision, namely Law No. 448 of December 23, 1998 – Public finance measures for stabilization and development (as amended by Law No. 108/2021 and Decree-Law No. 21/2022) – establishes that the conversion of surface right into full ownership shall take place upon payment of a fee ($C_{c.48}$) determined as follows:

$$C_{c.48} = (60\% MV_{area} - C_0) \tag{1}$$

where:
- MV_{area} is the fair market value of the asset, that is, the market value of the buildable land at the date on which the transfer deed is being executed;
- C_0 are the fees paid for the concession of surface right, revalued based on the change – ascertained by Italian National Institute of Statistics (ISTAT) – in the consumer price index for households of workers and employees, occurring between the month in which the mentioned fees were paid and the month in which the deed of transfer of the land is carried out.

The removal of the restriction on the maximum sale price, as defined by Decree No. 151 of September 28, 2020 – Regulation concerning the removal of price constraints on properties built under the regulated housing scheme (20G00168) (Official Gazette General Series No. 280 of November 10, 2020) – is subject to the payment of an amount determined as follows:

$$CRV = C_{c.48} Q_M 0.5 \frac{(ADC - ATC)}{ADC} \tag{2}$$

where:
- Q_M is the pro-rata share (in thousandths) of the housing unit;
- *ADC* is the number of years of the agreement's duration;
- *ATC* is the number of years, or fraction thereof, elapsed from the agreement's start until the maximum duration of the concession.

In the case of an agreement concerning the transfer of surface right with a duration between 60 and 99 years, the previous provision becomes:

$$CRVs = CRV0.5 \tag{3}$$

Ultimately, according to the current legislation, the amount to be paid to convert the surface right into full ownership, with the simultaneous removal of the restriction on the maximum sale price, is:

$$I_{Lex} = C_{c.48} + CRVs = C_{c.48} + 0.5 \bullet 0.5 C_{c.48} Q_M \frac{(ADC - ATC)}{ADC} \tag{4}$$

$$= (60\% MV_{area} - C_o) \left[1 + 0.25 Q_M \frac{(ADC - ATC)}{ADC}\right] \tag{5}$$

The legal framework is easy to apply and takes into account factors such as the duration of the concession and its remaining term, the fees paid at the time of establishing the surface right, and the value of the property at the date of conversion into full ownership; however, although the formulas consider macroeconomic elements through the ISTATFOI index, they use a series

of external coefficients whose origin is neither based on appraisal logic nor linked to the evolution of the real estate market.

5.2 Market approach

Setting aside the regulatory framework, and instead adopting market-based logic, the amount to be paid for the conversion of the surface right into full ownership is equal to the difference between the market value of full ownership (MV) and that associated with the surface right (MV_{sup}):

$$I_{Market} = MV - MV_{Sup} \quad (6)$$

The market value of a dwelling subject to a surface right, in the absence of specific regulatory guidelines, is equal to the initial accumulation of constant, deferred, and limited annual payments, i.e. the annual lease fees. Similarly, the market value of a property in full ownership, determined indirectly through the income capitalization method, is equal to the ratio between the annual payments and the capitalization rate. In formula:

$$I_{Market} = MV - MV_{Sup} = \frac{a}{r} - a\frac{q^n - 1}{q^n r} = \frac{a}{r}\left(1 - \frac{q^n - 1}{q^n}\right) \quad (7)$$

where:
- a is the annual rent;
- r is the discount rate, equal to the capitalization rate;
- $q = 1 + r$ is the unitary principal and interest;
- $n = ADC - ATC$ is the remaining duration of the concession.

The equivalence between the discount rate, used to estimate the market value of the property under surface right conditions, and the capitalization rate, used to estimate the market value of the property in full ownership, is made possible because: *i)* the fees are not indexed; *ii)* the remaining duration of the concession is always greater than 40 years (as explained below in the case study); *iii)* the opportunity cost, represented by the two rates in the two different situations, is practically the same since they refer to the same property, whereas the number of years in which the right holder receives the rent represents the only difference.

This approach is easily implementable as it is based on parameters referring to the analysis date and thus easily determinable; however, the main limitation of the market approach is that it does not consider that the current value of the property is closely linked to investments made by the surface right holders over the years, which should be partially deducted from the amount thus determined, and it doesn't take into account the fees paid at the time the surface right was established.

5.3 Compensation approach

In this work, a third approach called compensation is proposed. At the time of establishing the surface right, the holders/assignees are required to comply with restrictions on the transfer of the properties. The rationale behind these restrictions is inherently connected to the lower price of the dwelling, which is closely linked to the reduced price paid for the buildable land on which the properties are constructed. To convert the surface right into full ownership, the community should be compensated for the initial advantage through a payment equal to the difference between the market value of the buildable land in the year the agreement is signed ($MV_{Area,i}$) and the fees paid at the initial time of the concession (O). By applying the rules of financial mathematics, this difference should be brought forward to the date of conversion of the surface right into full ownership using the actualization factor; in formula:

$$I_{Compensation} = (MV_{Area,i} - O)(1 + i)^t \quad (8)$$

where:
- i is the annual interest rate;
- t is the time in years elapsed between the date of establishment of the surface right and the date of its conversion into full ownership.

In practice, this approach aims to return to the community the plusvalue initially recognized to the assignee-surface right holders($MV_{Area,i} - O$) assuming that, purely theoretically, the surface right holder has invested this saving in a lowrisk investment.

The application of the compensation approach faces the difficulty of determining the market value of the buildable land at the date of establishment of the surface right, since PEHP areas were developed starting around 1970, with their greatest expansion in the 1980s. During those years, there were no selling price listings currently compiled semiannually by the Real Estate Market Observatory (OMI) of the Italian Revenue Agenc , and it is difficult to find sale prices from which to derive $MV_{Area,i}$. Furthermore, the question concerns the interest rate to be included (for example, government bond yields, savings bonds) and whether to use a fixed rate or differentiate it based on the year the right was established.

6. CASE STUDY

6.1 Analysis of the initial database

In order to determine the amount required for the conversion from surface right to full ownership, the necessary information for applying the three approaches (I_{Lex}, I_{Market} e $I_{Compensation}$) relating to the 15 most populous Italian municipalities (Rome, Milan, Naples, Turin, Palermo, Genoa, Bologna, Florence, Bari, Catania, Verona, Venice, Messina, Padua, and Trieste) have been collected. Following consultations with the technical departments of the municipalities, positive feedback has been received from the cities of Bari, Florence, Genoa, Turin and Verona, which have provided data regarding 96 areas where public housing developments (*Edilizia Residenziale Pubblica*, ERP) have been carried out between 1976 and 1998.

All the municipalities, except the city of Verona, are regional capitals. As Figure 1 shows, the city of Bari is located in Southern Italy, Florence in Central Italy, Verona in the North-East, whereas the cities of Turin and Genoa are in the North-West cluster. According to ISTAT data updated as of 01/01/2025 (Table 1), the most populous municipality is Turin, which also has the highest population density, whereas the least populous is Verona, which also has the lowest density. The municipal territory of Genoa is the most extensive, while Florence and Bari are comparable both in terms of surface area and number of residents.

The technical offices of the five municipalities have provided the following information: *i)* area address, *ii)*

Figure 1. Localization of the five Italian cities selected for the analysis within the national territory.

Table 1. Area, population and population density of the case study related to the five Italian cities.

ID	Case study	Population	Area (Km²)	Population density (ab/Km²)
1	Bari	315,473	115.93	2,721.24
2	Florence	362,353	102.22	3,544.83
3	Genoa	563,947	239.9	2,350.76
4	Turin	856,745	130.11	6,584.77
5	Verona	255,133	198.86	1,282.98
	TOTAL	2,353,651	787.02	

year of establishment of the surface rights, *iii)* fees paid, *iv)* built volume or surface area, and *v)* duration of the concession. To standardize these data, volume has been converted to surface area by assuming a floor-to-floor height of 3 meters. In most cases, the construction refers to the Gross Floor Area (GFA), which is an urban planning parameter whose definition and determination vary depending on the applicable building regulations.

The total GFA of the 96 areas is 680,981 m², with an average of just over 7,000 m². The minimum GFA of 670 m² is found in the municipality of Florence, while the maximum, 77,350 m², is in the municipality of Genoa. The city with the highest number of analyzed areas is Florence, followed by Genoa, Verona, Bari, and finally Turin (Table 2).

The greatest development of PEHP interventions has occurred around the 1980s: even in the analyzed sample, the 1980-1982 period accounts for the highest number of areas (39), corresponding to a GFA of almost 277,889 m² (40.8% of the total). Regarding the last decade analyzed (1989-1998), only 12 areas have been developed, totaling a GFA of just 95,798 m² (14.1% of the total) (Figure 2).

The geographical distribution of the cities, their size, the number of provided areas and the considered time interval make the analyzed sample adequately representative of the investigated phenomenon.

The duration of the concession is 99 years in 81% of cases and 90 years in the remaining 19%; the total fees paid amount to nearly 9.5 million euros, corresponding to a unit cost per m² of GFA of 21.8 €/m² , with a minimum of 0.43 €/ m² in Bari and a maximum of 170.4 €/ m² recorded for the city of Verona. The graphs showing absolute and cumulative frequencies (Figure 3) reveal that in 47% of cases, the initial fees paid are less than 5 €/m², in 36% between 5 and 35 €/m², in 11% within the range 35-100 €/m², and rarely (5%) exceed 100 €/m² (Figure 3).

6.2 Improvement of the initial database

In order to generalize the three approaches, useful for their subsequent comparison, commercial surface unit (CS) has been considered: the CS is the most widely used parameter for direct estimates, as it is considered more representative of the market's appreciation of the different surfaces included in the property. For its determination, the references provided by OMI of the Italian Revenue Agency (Central Directorate of the Real Estate Market Observatory, 2016) can be used, which are applied in defining the value ranges of the different homogeneous market micro-zones. As previously introduced, the fees paid at the time of establishing the surface right refer to the GFA, while the OMI of the Italian Revenue Agency quotations refer to the CS: since it is not possible to establish a coefficient for converting GFA to CS, equivalence between these parameters has been assumed. The current legislation uses the thousandth share associated with each housing unit as the base parameter for determining the conversion fee. Simplistically, it has been considered that the ratio between the GFA of the individual property and the total GFA of the analyzed area corresponds to the equivalent ratio between commercial surfaces and ultimately to the thousandth share.

After georeferencing the areas, the initial database has been enriched with value quotations related to sales

Table 2. Main data of the areas located in the five selected Italian cities.

Case study	N	GFA (m²)	GFA_average (m²)	GFA_min (m²)	GFA_max (m²)	Fees paid (€)	Unitary fees_average (€/m²)	Unitary fees_ min (€/m²)	Unitary fees_ max (€/m²)
Bari	12	39,884	3,324	860	9,196	1,043,855	23.8	0.4	117.8
Florence	45	147,949	3,288	670	13,511	2,655,223	16.5	0.5	78.3
Genoa	18	250,574	13,921	1,083	77,340	859,096	4.3	1.4	21.1
Turin	4	137,568	34,392	7,248	46,905	1,101,817	13.1	2.1	33.7
Verona	17	105,006	6,177	1,333	17,400	3,866,487	55.1	4.7	170.4
TOT.	96	680,981	7,094	670	77,340	9,526,479	21.8	0.4	170.4

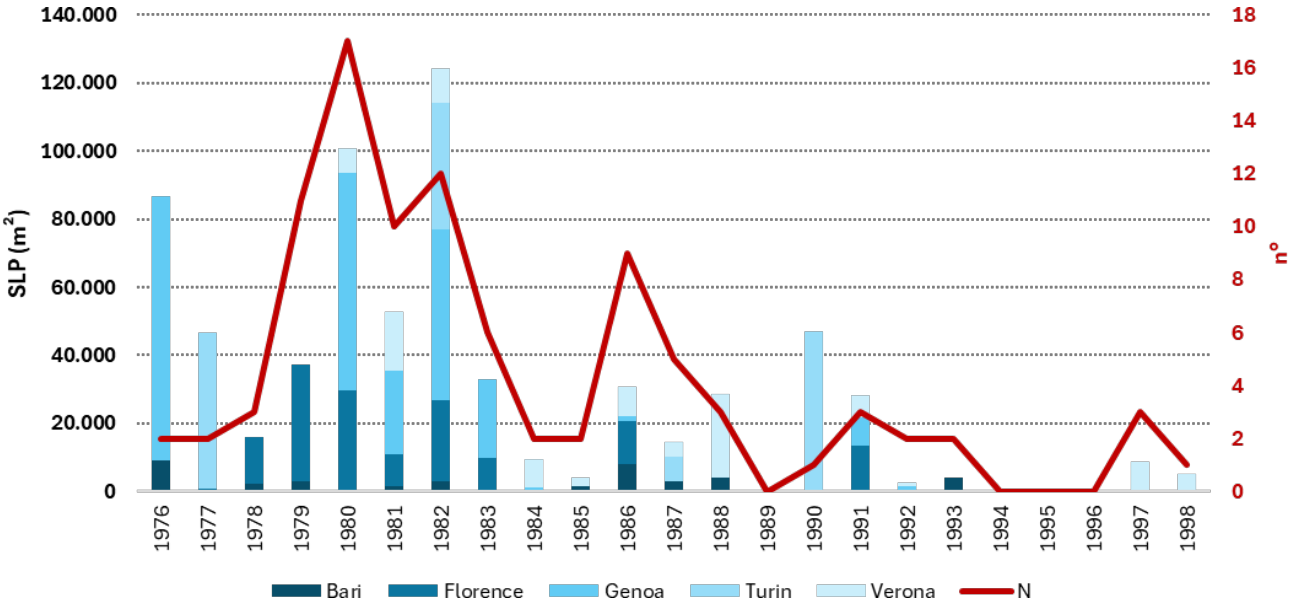

Figure 2. Number and surface area of the analyzed areas divided by city and year.

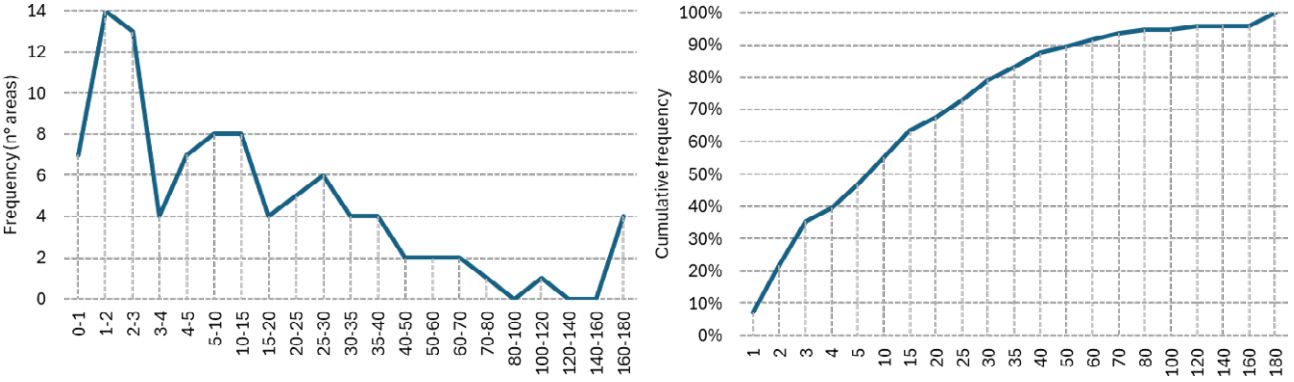

Figure 3. Absolute and cumulative frequency associated with the ranges of fees paid at the time of establishment of the surface right.

and rentals of "civil" and "economic" housing provided by the OMI of the Italian Revenue Agency for the second half of 2024. Only for some micro-zones in the municipality of Verona, OMI does not provide rental information for economic housing: in this case, rental values have been reconstructed using the capitalization rate applied to civil housing located in the same context. Moreover, for the "E3 - SACRA FAMIGLIA, CA` DI DAVID" micro-zone in the city of Verona, OMI only provides information for civil-type properties, therefore only this category has been taken into account.

Assuming a reference date of December 31st, 2024, for the application of the first approach (I_{Lex}), in addition to the data provided by the technical offices, the identification of the national consumer price indices for worker and employee families provided by ISTAT (FOI-Istat) is needed. Specifically, these indices allow the adjustment of fees paid from the year of establishment of the surface rights to the present date (Figure 4).

Through an overlay between the locations of the areas and the market micro-zones elaborated by OMI, it is highlighted that for all analyzed municipalities, the PEHP areas are located in residential suburbs; specifically, the areas in Bari are spread across 8 micro-zones, Verona in 7, Genoa in 6, Florence in 5 and Turin in 3 (Figure 5).

Finally, the calculation of I_{Lex} requires estimating the market value of the area at the hypothetical date of December 31st, 2024 (MV_{Area}). This market value can be determined by assessing the revenues (sales of the new

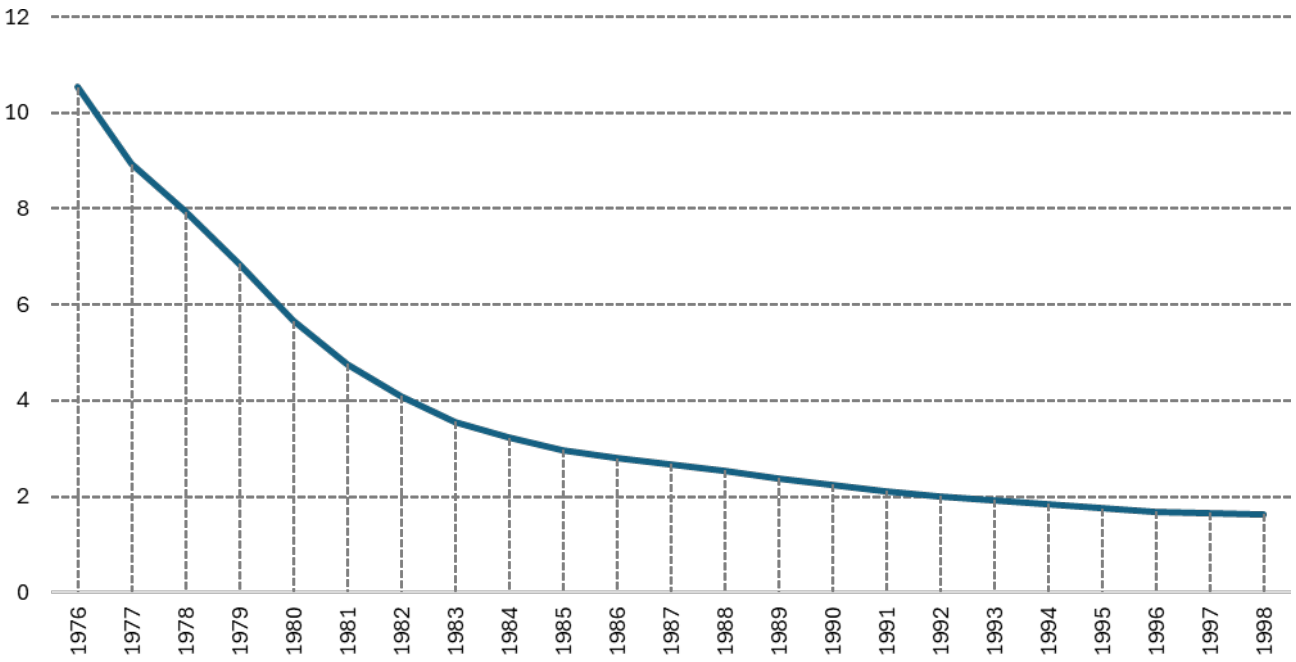

Figure 4. FOI-ISTAT coefficients to transform monetary values of indicated periods into 2024 values (ISTAT data representation).

buildings) and the costs (construction, urbanization and financial charges, overheads, profits, etc.) generated by the transformation initiative carried out on the land by an ordinary investor. Since the detailed information data necessary to apply this method are not known, the incidence of the land value compared to the total property value can be considered as a simplification. By taking into account the land swaps in favor of landowners in residential development cases and some municipal resolutions applied for determining expropriation indemnity in social housing interventions, this coefficient has been set at 15%.

Therefore, the mathematical relationship is expressed below:

$$MV_{Area} = 15\%\ Q_{MIN} \tag{9}$$

in which Q_{MIN} is the minimum quotation for residential properties of the economic type reported by OMI for the micro-zone in which the analyzed area is included.

For the application of the market approach (I_{Market}) the minimum OMI quotation associated with the lease of economic-type properties has been used instead of the annual rent ($a = L_{MIN}$), and the ratio between Q_{MIN} and L_{MIN} to determine the capitalization rate ($r = Q_{MIN}/L_{MIN}$).

To determine the market value of the area at the date of establishment of the surface right ($MV_{Area,i}$), useful for the implementation of the compensation approach ($I_{Compensation}$), the same approach previously introduced for MV_{Area} has been adopted. Thus:

$$MV_{Area,i} = 15\%Q_{CI} \tag{10}$$

in which Q_{CI} represents the nominal values provided by the magazine "Il Consulente Immobiliare", published by "Il Sole 24 Ore" in the year of establishment of the surface right, adjusted as described below. Q_{CI} is an average quotation published biannually and associated with the central and peripheral zones of the main Italian cities. To harmonize this information with the data required, a new semi-central zone has been hypothesized, whose value is the average of the previous zones, and the values for the missing years have been reconstructed as the average of the observations for the previous and following years. Furthermore, since the context is economic housing, this value has been divided by a coefficient of 1.25, obtained as the average ratio between OMI quotations for civil-type dwellings and those for economictype ones. The interest rate needed to temporally transform the amounts into a present value could correspond to the net yield of government securities (BTP and BOT) issued by the Ministry of Economy and Finance – Treasury Department. This yield was over 10% during the 1970s and 1980s (periods marked by high inflation and low liquidity), whereas currently it is around 2%. As a precautionary measure, the latter rate (i.e. 2%) has been chosen to avoid excessively penalizing the superficiaries.

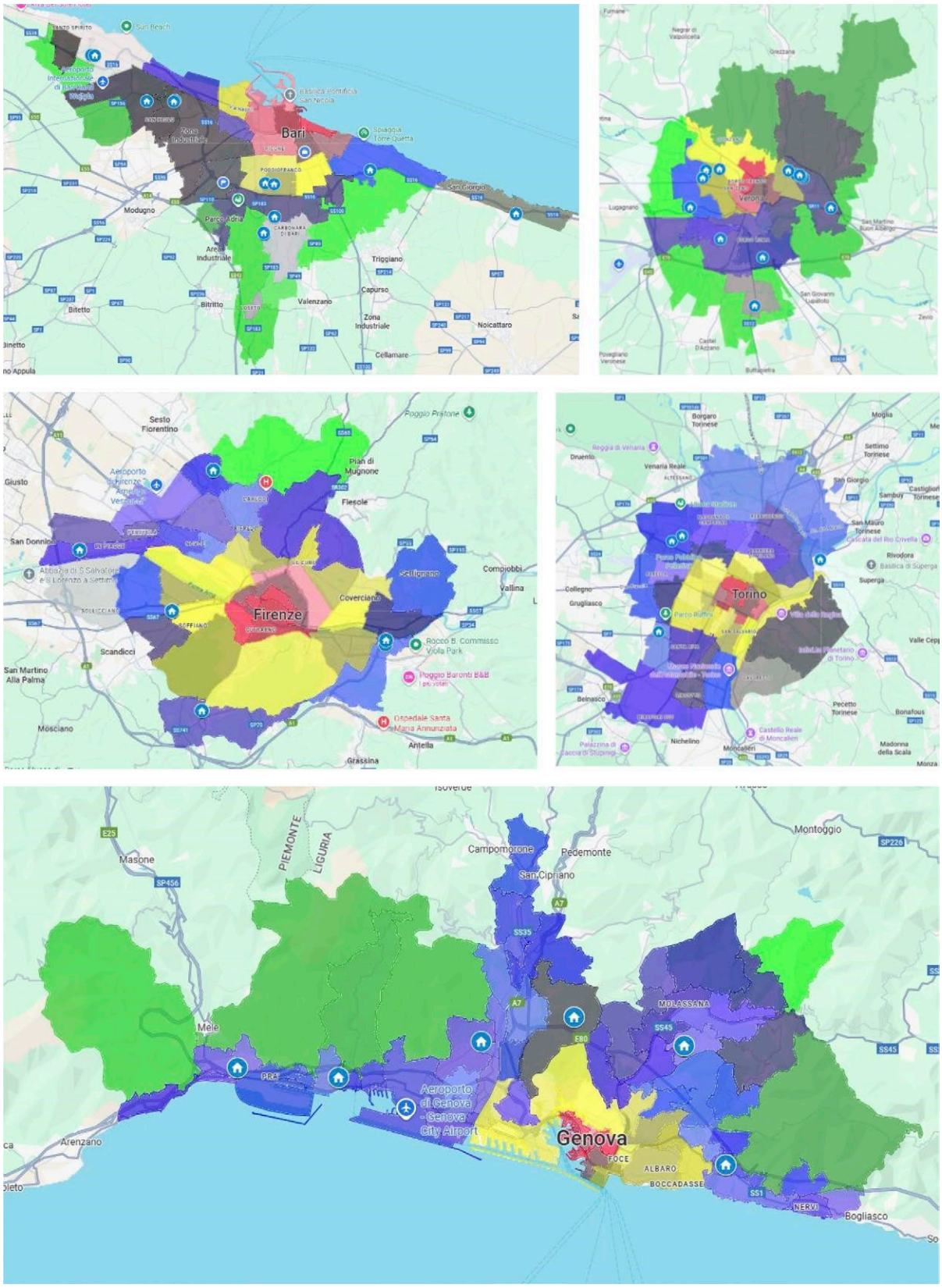

Figure 5. Representation of the investigated PEHP areas in the five cities and of the micro-zones developed by OMI.

6.3 Application of the three approaches

The database has allowed the determination of I_{Lex}, I_{Market} e $I_{Compensation}$ for the 96 cases: for 60 of the 96 areas, the approach that generates the highest amount payable by the superficiary to become the owner is linked to the market logic. For 34 areas, by implementing the compensation approach the highest conversion fee is obtained, whereas for only 2 areas, the legal-based approach determines this result. In 7 situations, the superficiary should pay nothing if referring to the compensation approach, and in 16 cases by considering the legal-based approach (Figure 6). In the city of Florence, the most penalising approach for the superficiary is usually the market approach; in the city of Turin, the compensation approach generates a higher payment for all areas. In Genoa, the market approach proves to be the worst in 55% of cases, while the compensation approach is less preferred in the remaining 45%. In the cities of Bari and Verona, the highest amount is mostly determined using the compensation approach, only occasionally through the market approach, and for just one area by means of the legal-based approach (Figure 7).

As shown in Table 3, excluding cases where the amount payable is zero, the minimum compensation - equal to 9€/m² - and the maximum - equal to 385€/m² - are both determined through the compensation approach. The average amounts are equal to 109€/m² for the legal-based approach, 120€/m² for the compensation approach, and 162€/m² for the market approach.

By assuming that all superficiaries become owners, this would generate revenue for the Public Administration of nearly 54 €million according to the legal-based approach, 92.5 €million according to the market approach, and 80.6 €million according to the compensation approach.

From this initial analysis of the results of the three approaches, it is evident that the compensation approach occupies an intermediate position between the legal-based and market approaches. Through correlation analysis, it is possible to highlight that the market approach and the compensation one are not correlated, whereas the legal-based approach shows a weak positive correlation with the other two.

7. CONCLUSIONS AND FUTURE DEVELOPMENTS

The need to address the housing emergency in Italy during the 1970s led to the creation of PEHP zones, which aimed to provide housing at prices below market value to individuals who could not access the free market. This situation was made possible through the expropriation of land, generally by municipalities, and its subse-

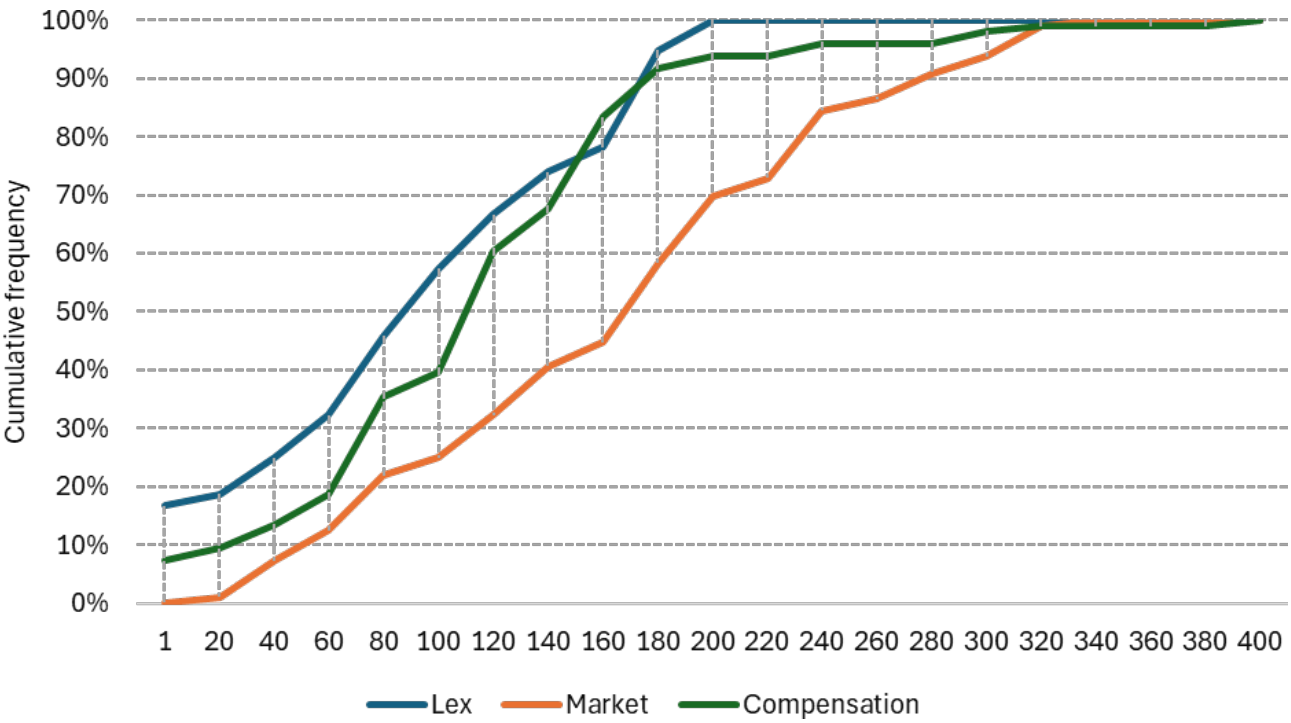

Figure 6. The highest amount payable by the superficiary according to the three approaches.

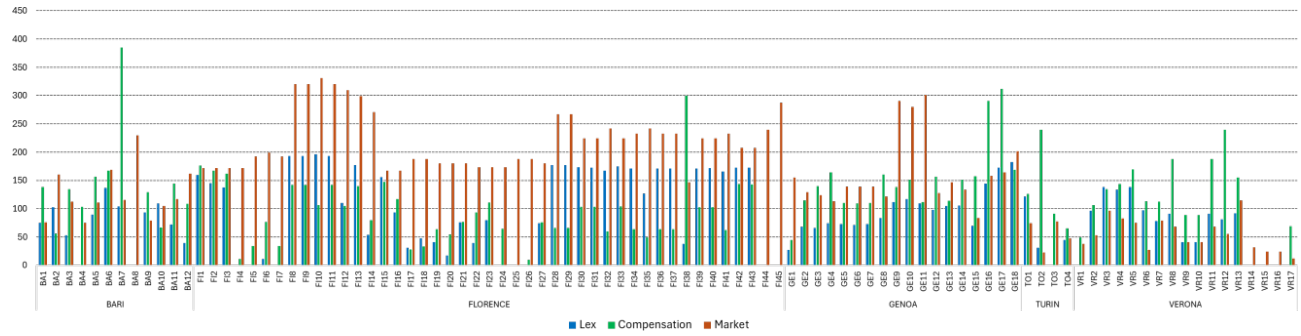

Figure 7. Comparison of the three approaches 'results for each area.

Table 3. Comparison of the results deriving from the application of the three approaches.

	Lex	Market	Compensation
MIN* (€/m²)	11	12	9
MAX (€/m²)	196	331	385
MED (€/m²)	109	162	120
ST. DEV. (€/m²)	62	81	70
Revenue (€)	53,971,104	92,547,574	80,605,543

* excluding the value 0.

quent allocation to cooperatives following the payment of a fee lower than the market value of the land. This mechanism was often linked to the simultaneous creation of the surface right for the housing assignee, implicitly allowing the municipality – having become the landowner – to potentially regain possession of the dwelling in the future (Locurcio et al., 2025; Tajani et al., 2025). Over time, this prospect proved difficult to implement, and successive governments facilitated the conversion of the surface right into full ownership upon payment of a corresponding fee.

Within this framework, the present work has critically analyzed the approach established by current legislation, comparing the fee determined according to its application with the purely market-based logic and with the approach connected to the legitimate need to compensate the community for the initial advantage granted to the assignee-surface right holders. Through a case study involving 96 PEHP areas located in five Italian municipalities, the fees determined according to the three approaches have been compared to highlight the disparities caused by the current legislation and the potential increased revenues for the Public Administration that could be generated if the approaches proposed by the authors have been applied. The research offers practical guidance for defining a fair fee for converting surface rights into full ownership by integrating market-based criteria and the initial advantage granted to beneficiaries. This approach helps reduce disparities generated by current legislation, enhances consistency in administrative decisions, and can improve the financial sustainability of public administrations by identifying potential additional revenues. Moreover, it provides policymakers with a data-driven tool to design more equitable and effective housing policies, with potential applicability beyond the Italian context. However, the potential of the proposed approach, called compensation, faces limitations related to identifying the necessary data for its wide-scale application, especially when operating in small municipalities with stagnant real estate dynamics and difficulties in obtaining objective real estate information referring to the date of establishment of the surface right. These limitations could be overcome by identifying, through a regression-based approach, a predictive function that yields results comparable to those of the compensation approach by using proxy variables in place of the market value of the land at the date of establishment of the surface right - for example, by using coefficients representing real estate trends such as the House Price Index referring to nominal prices. This future development, particularly if built on a larger sample, would overcome the arbitrariness of the coefficients to be used in the current legal-based approach, creating a fair model based on compensating the actual advantage granted to surface right holders, free from logics connected to the specificities of different real estate markets.

AUTHORS' CONTRIBUTION

This work should be attributed equally to the authors.

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AESTIMUM
CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Firenze University Press
www.fupress.com/ceset

OPEN ACCESS

Citation: Battisti, F., Pisano, C., Campo, O., Perdonò, M. & Mele, D. (2026). Metabolic approach and Life Cycle Assessment in building an energy community: the case of the Mondeggi Estate in the Municipality of Bagno a Ripoli. *Aestimum* 88: 87-110. doi: 10.36253/aestim-17761

Received: April 23, 2025

Accepted: May 15, 2025

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Metabolic approach and Life Cycle Assessment in building an energy community: the case of the Mondeggi Estate in the Municipality of Bagno a Ripoli

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Abstract. The "urban and territorial metabolism" refers to the construction of urban systems by analyzing the directions of energy, water, nutrients, materials, and waste flows in an urban system, with the aim of quantifying the inputs, outputs, and stored parts of the system. In short, it is an evaluative-design approach to the stability and impact of a production system, with the aim of verifying its results in terms of sustainability. The transition from linear production-consumption approaches to circular systems, now accepted by various European public administrations, represents a new direction in the processes of regeneration and transformation of the territory, in order to improve the quality impact of urban and peri-urban areas and meet the environmental objectives set out in the European agenda. On this basis, in developing the meta-project for the eco-sustainable restructuring and functionalization of the Mondeggi Public Estate, this article aims to use a metabolic approach to define the conditions for achieving the overall environmental, social, and economic sustainability of the Mondeggi Estate's systems. Specifically, the metabolic approach defined to safeguard and maintain natural and ecosystem resources over time, without producing irreversible alterations, is evaluated through a Life Cycle Assessment considering the relationship between the flows of resources (firstly energy, even considering water) that the 'Tenuta di Mondeggi' system absorbs and produces.

Keywords: landscape, environment, metabolism, Life Cycle Assessment, energy community.

1. INTRODUCTION

Urban territorial systems based on the traditional linear economic model – "extract, produce, use, and dispose" – have given rise to several pressing

societal challenges (Fernandes and Ferrão, 2023; Perrotti and Stremke, 2017).

The lack of coordinated and circular planning has produced urbanization models that fail to manage nonrenewable resources and raw materials effectively (Brown et al., 2017). These shortcomings have contributed to climate change and rising global temperatures, significantly undermining residents' quality of life and the resilience of territories, as reflected in recent well-being indicators (Cinquepalmi, 2019).

The exponential growth of the global population, now surpassing 8 billion, combined with the ongoing abandonment of inland and rural areas and recent technological and economic developments, has significantly contributed to urban overcrowding. This scenario exacerbates the challenges of managing energy, resources, and material flows (Paoli and Pirlone, 2024).

In this context, issues related to the supply of fossil resources become crucial globally, especially for countries that lack these resources within their territory. This situation has made energy dependence a central theme in national debates across many states of the European Union (ENEA, 2011).

The European Union's substantial reliance on offshore energy supplies remains one of its most pressing challenges. The EU continues to depend heavily on imports of natural gas and oil (GEA, 2012). This vulnerability is further exacerbated by fossil fuels being primarily imported from countries with high geopolitical risk profiles (ENEA, 2011). Scientific literature consistently shows that a nation's energy security is significantly weakened when dependence is high and when imports are concentrated among a small number of suppliers with low geopolitical stability (Gross and Mautz, 2015; Magnani, 2018). Moreover, reliance on cross-border primary energy sources affects not only the resilience of the energy system but also a country's overall security and competitiveness.

Heavy reliance on fossil fuel imports from non-EU countries exposes many EU Member States to significant fuel price volatility. These price fluctuations directly impact electricity costs and hinder environmental sustainability, as external fossil fuel use remains a major driver of greenhouse gas emissions and other environmental pressures.

This context calls for a sustainable rethinking of urban systems, including the diversification of energy sources, as demonstrated by recent policies supporting renewables, the development of efficient and circular models, and, ultimately, the diversification of fossil fuel supplier countries (Aura, 2022; Khan, 1995; Pluchino, 2019).

To strengthen the methodologies used for analyzing, evaluating, and designing urban systems based on circular economy principles – defined as an economic model capable of self-regeneration and long-term sustainability (Bortolotti et al., 2023) – it is advisable to adopt the urban metabolism approach (Castán Broto et al., 2012; Kennedy, 2007). This framework enables the analysis of energy flow inputs and outputs within cities or specific urban areas. Moreover, it serves as a design tool for implementing circular, resilient, and sustainable urban models, improving energy system efficiency, and helping mitigate the impacts of climate change.

Urban metabolism aligns closely with key European energy strategies, including the "2030 Framework for Climate and Energy" (European Commission, 2014) and the "Long-term Strategy for 2050" (European Commission, 2018). These frameworks are designed to meet the targets established by the Paris Agreement, which include: (*i*) keeping the global temperature increase below 2°C, with efforts to limit it to 1.5°C; (*ii*) reducing greenhouse gas emissions by at least 55% compared to 1990 levels, surpassing the previous 40% target (Kennedy et al., 2011); (*iii*) increasing the share of energy consumption from renewable sources to at least 32%; and (*iv*) improving energy efficiency by a minimum of 32.5%.

Italy is among the EU countries facing significant energy dependency, fossil fuel use, and waste management challenges.

At the national level, the National Energy Strategy (SEN), published in late 2017, established long-term policy guidelines aligned with EU goals and called for a a reduction of emissions by at least 80% compared to 1990 levels.

The SEN also led to the adoption of the Integrated National Energy and Climate Plan (NECP) 2021-2030, a strategic framework structured around five key pillars: (*i*) decarbonization; (*ii*) energy efficiency and security; (*iii*) development of the internal energy market; (*iv*) research and innovation; and (*v*) competitiveness.

Municipalities play a central role in climate action at the local level through the Covenant of Mayors for Climate and Energy, which sets a target of a 40% reduction in greenhouse gas emissions by 2030. Italian municipalities implement this commitment through the Sustainable Energy and Climate Action Plan (PAESC), adapting climate goals to local contexts and resource availability (Bolognesi, 2018). These strategies recognize that achieving the energy transition requires acting on multiple fronts, including increasing renewable energy production, reducing emissions, and lowering energy demand. One promising avenue is the development of energy communities (Tucci et al., 2024; Galán-Cano et al., 2025).

The construction of energy communities offers a chance to address the social acceptability of energy interventions and move beyond the traditional sectoral approach, fostering locally defined energy mixes, tailored to resource availability. In dynamic energy communities, inhabitants engage in identifying heritage resources, assuming a lead role in managing their territory's transition towards self-sustainability (Biggeri et al., 2023; Pisano, 2021). Core principles of energy communities include decentralization and localization of energy production. Involving citizens, businesses, and local enterprises enables energy production, consumption, and exchange focused on self-consumption and collaboration (ENEA, 2021).

The development of local energy communities in Italy can serve as a pathway to constructing metabolic energy systems that enhance regional energy potential and generate alternative energy sources (Bolognesi and Magnaghi, 2020), thereby promoting greater energy independence. This initiative partially mitigates the deficit that currently hampers Italy's energy autonomy. Within this framework, an energy community possesses the capacity to function as an instrument for attaining national energy independence in a scenario where the Italian landscape encompasses a network of such communities.

The significance of this tool/model can be understood by referencing the Italian case study and briefly examining the data regarding domestic energy production.

In 2021, Italy's electricity demand was recorded at 319.9 TWh, marking an increase of 6.2% compared to the previous year. Domestic production accounted for 86.6% of the electricity demand, while the remaining 13.4% was fulfilled through net imports from abroad, which rose by 32.9% from 2020. The gross domestic production reached 289.1 TWh, reflecting a 3.0% increase over 2020. Specifically, domestic generation consisted of 59.0% non-renewable thermoelectric generation (an increase of 5.5% relative to 2020), 16.4% from hydro generation (a decrease of 4.1% compared to 2020), and the remaining 24.6% was derived from wind, geothermal, photovoltaic, and bioenergy sources (with wind increasing by 11.5%, photovoltaic by 0.4%, geothermal decreasing by 1.9%, and bioenergy decreasing by 2.9% when compared to 2020). The renewable generation sector continued to expand in 2021, with an overall growth of 2.5%, representing 48.4% of the total installations in Italy. Conversely, the thermoelectric generation fleet slightly declined, decreasing from 62.7 GW in 2020 to 61.9 GW. In quantitative terms, the number of renewable installations increased from 948,979 in 2020 to 1,029,479 in 2021, with the photovoltaic sector registering an increase of 80,245 installations. Various sectors demonstrated growth over the preceding year, with photovoltaics increasing by 4.4% and wind power by 3.5%. Meanwhile, the hydro renewable sector experienced a modest increase of 0.3%, reaching 19.2 GW; the bioenergy (4.1 GW) and geothermal (0.8 GW) sectors remained stable. Additionally, as of December 31, 2021, there were 75,070 operational storage systems, reflecting a 90% increase compared to 2020, with a total nominal active capacity of 407.1 MW, representing a 124% rise compared to 2020 (TERNA, 2021).

The above data suggest that, despite a significant decline, the still high national dependence on nonrenewable energy sources presents an issue that requires prompt and practical solutions.

This research endeavors to delineate the methodology for establishing a metabolic energy community, utilizing the Mondeggi Estate in Bagno a Ripoli, a public property under the jurisdiction of the Metropolitan City of Florence, as a case study.

In detail, it aims to understand and explore the potential of local energy systems based on urban metabolism and circularity principles. It utilizes the energy community model by planning alternative energy production facilities tailored to a specific local system's spatial energy potential and energy demand.

The study was conducted as part of a collaboration between the DIDA and DISEI departments of the University of Florence and the Metropolitan City of Florence. The outcome was a Technical-Economic Feasibility Project, which was submitted for funding under the Integrated Urban Plans supported by NRRP.

The area being tested was the focus of a project proposal for environmental, architectural, social, and cultural redevelopment through the implementation of one of the project lines of the National Recovery and Resilience Plan (NRRP), which allocates resources to Metropolitan Cities for investments aimed at fostering better social inclusion in urban or suburban areas.

The process of building the energy community for the Mondeggi area followed an analytical approach articulated through in-depth research into the area's energy potential and needs to be met, the foreseeable production and waste production cycles, and the correlations between the basic components of urban metabolism (product, energy, waste) (Muñoz and Navia, 2018).

This study also considered landscape values and the citizens' perceptions of the area, also supported by the participatory process that accompanied the development of the project (Biggeri et al., 2023). From this point of view, the analyses also served as the basis for redefining the general perception of the area, enabling shared

envisioning and building support for the proposed ideas (Pisano and Lingua, 2021).

After this, a comprehensive series of metabolic intervention options was developed, meticulously calibrated in accordance with the relationship between available resources and the requisite needs to be addressed. Consequently, the final hypothesis was formulated, accompanied by a thorough assessment of the associated implementation costs.

A Life Cycle Assessment was conducted using One Click LCA Planetary software and the Net Zero Carbon application to evaluate the operational validity of the design process and the results obtained.

Based on the above, the following sections are outlined: Section 2 provides a literature review of the topics covered in the article and illustrates the LCA method used; Section 3 presents the results arising from the experiment, specifically the construction of an energy community on the Mondeggi Estate in the Municipality of Bagno a Ripoli; Section 4 presents the outcomes of the LCA conducted; and Section 5 discusses the experiment results and draws conclusions from the work.

2. MATERIALS AND METHODS

This section presents: *i*) the results of a literature review on the key topics addressed in this paper, including: 2.1) energy production, efficiency, and savings; 2.2) urban metabolism; *ii*) a description of the research methodology, covering: 2.3) The planning approach for energy communities, illustrated through the case study of the Mondeggi Estate in the Municipality of Bagno a Ripoli (Metropolitan City of Florence); 2.4) The application of Life Cycle Assessment (LCA) to evaluate the outcomes of the experiment.

2.1 Energy: production, efficiency, and savings

Addressing the energy performance of an urban system begins with understanding the amount of energy required to maintain its basic functions (Kennedy et al., 2011; Castán Broto et al., 2012). In line with current best practices in territorial planning and design, assessing the energy production potential from renewable sources is essential. At the same time, it is crucial to reduce energy consumption, particularly in infrastructure and service operations, transport, public lighting, and building management (ARSIA, 2009).

This approach seeks to diminish urban reliance on extensive, frequently remote energy infrastructures and fossil fuels linked to considerable market volatility and energy insecurity (Gross and Mautz, 2015). These factors exemplify the fundamental challenges of advancing energy conservation and using renewable energy sources efficiently. Originating from natural resources that are either inexhaustible or capable of regeneration within a human timescale, renewable sources afford significant advantages for environmental protection and public health and serve as a plausible alternative to fossil-based electricity generation.

Nevertheless, the emergence of new design models for local energy systems, such as energy communities, has largely been driven by the dynamics introduced by renewable energy sources (RES). This shift is often associated with large-scale installations that are disproportionate to the territorial context. These systems have been incentivised by policy frameworks and strategically leveraged by industry operators seeking to reduce costs and maximise the efficiency of individual energy sources (Mushafiq et al., 2023).

Thus, the most common strategy for reducing costs has been the development of large-scale facilities, such as ground-mounted photovoltaic systems comprising hundreds or even thousands of panels, geothermal plants, and large wind farms (Gross and Mautz, 2015).

Recently, growing concerns about the impacts of large-scale energy infrastructures have opened new avenues for rethinking energy production and consumption. This shift has encouraged the emergence of a cultural approach that links renewable energy generation to localized energy configurations (Conde and Takano-Rojas, 2025).

This necessitates exploring innovative approaches to execute interventions aimed at energy conservation and energy efficiency that, although functioning distinctly, aspire to attain comparable and synergistic outcomes. Among these, the focal point of this article is urban metabolism.

Before turning to the literature review on urban metabolism, it is important to distinguish between the two concepts established at the normative level by European Directive 2012/27/EU, which defines them as follows:

i) "energy savings, amount of energy saved, determined by measuring and/or estimating consumption before and after implementation of an energy efficiency improvement measure, while ensuring normalization of external conditions affecting energy consumption".

ii) "energy efficiency, the ratio of output in terms of performance, services, goods, or energy to the input of energy".

Common energy-saving measures include reducing energy needs by adopting "virtuous" behaviors such

as limiting heating and lighting usage, using household appliances efficiently, and regulating winter heating and summer air conditioning temperatures.

On the other hand, a system's energy efficiency represents its ability to optimize energy utilization to meet a given demand.

Enhanced efficiency enables the same result to be achieved with reduced energy consumption. In contrast to savings, energy efficiency is quantifiable, typically expressed as a percentage or through a building's energy class rating. This rating provides insights into construction quality, particularly insulation and technological systems, and, more importantly, helps identify the most effective interventions to enhance overall performance (Sorgenia, 2022).

2.2 Urban metabolism

Comparing the city to a living organism has been a significant aspect of urban studies and technology for many years. The term "metabolism" defines the set of chemical reactions occurring within each cell of a living organism, providing energy for life processes and synthesizing new organic material. Living organisms transform what they extract from their environment into energy into energy for activities such as development, movement, and reproduction (Wolman, 1965).

This is precisely why the need arises to understand the workings of processes within urban systems; that is, how the city utilizes energy and matter to support its inhabitants.

In analogy to biological metabolism, it is possible to construct a model that facilitates descriptions and analyses of the incoming and outgoing (input and output) exchanges of flows, materials, and energy related to cities and the territories they occupy, studying the interactions between urban infrastructure and services, as well as those between natural systems and the human species (Wolman, 1965).

This methodology was first systematized by Abel Wolman in 1965 to analyze the direction of energy, water, nutrient, material, and waste flows in an urban system, quantifying the inputs, outputs, and stored components within the system. This methodology assesses the stability and impact of a production system to determine its overall resilience and sustainability.

Wolman conducted his research using a hypothetical city of one million residents, focusing on quantifying resource inputs and waste outputs. He described "urban metabolism" as encompassing all materials and resources required to support a city's residents at home, at work, and during leisure activities.

Since Wolman's work, research on urban metabolism has intensified, and some cities have adopted this approach to study their resource flows to improve efficiency, sustainability, and resilience.

Recently, researchers at the University of Toronto conducted a comparative study on urban metabolism across eight metropolitan regions. This study identified various processes that present a significant threat to urban sustainability, including the formation of heat islands, alterations in groundwater levels, the accumulation of nutrients such as phosphorus and nitrogen, the production of toxic materials, and the depletion of local raw materials (Kennedy et al., 2011).

This research redefines urban metabolism as the sum total of technical and socioeconomic processes occurring in cities, reflecting growth, energy production, and waste disposal (Kennedy et al., 2011). This approach provides a useful interpretive key for understanding the city's complex dynamics and redesigning it sustainably.

Over the years, the urban metabolic approach has evolved from a purely spatial monitoring tool focused on studying urban energy and material flows into a sophisticated method that uses monitoring data to develop small-scale design models centered on circularity, material reuse, and environmental sustainability.

Today, contemporary urban planning fully embraces the idea of urban and spatial metabolism (e.g., Kennedy et al., 2011; Van Bueren et al., 2012; Ibañez and Katsikis, 2014; Sijmons et al., 2014). Urban planners and decision-makers currently apply the urban metabolism model across four main practical domains:

i) Sustainability reporting: this model facilitates the reporting, analysis, and comparison of impacts, resource reserves, and sustainability levels in cities globally, presenting data in a manner that is accessible to decision-makers and allows for comparisons over time;

ii) Greenhouse gas accounting: this model quantifies greenhouse gas emissions in urban areas, reflecting resource consumption and waste. By utilizing relevant indicators, such as the previously mentioned carbon footprint, it is feasible to pinpoint emissions surpassing expected limits and formulate suitable action plans for their reduction;

iii) Analysis of strategies: urban metabolism has created mathematical models to measure and forecast the amounts of pollutants and nutrients in the urban environment. Utilizing these simulations allows for the identification of effective pollution prevention strategies and the assessment of their efficacy;

iv) Sustainable urban planning: utilizing the previously mentioned applications, the urban metabolism model serves as a design tool for creating and executing

more sustainable urban infrastructure and services. By monitoring the flow of energy, materials, and waste within the system and combining this information with social, health, and economic indicators, it becomes possible to devise strategies for urban regeneration. This is achieved by establishing a circular metabolism where resources are reclaimed and waste is reduced (Kennedy et al., 2011; Paoli and PirlPirlone, 2024; Pluchino, 2019).

Considering the previously mentioned applications, we aim to propose a methodological framework for designing a local metabolic energy system to be integrated with the energy community tool.

2.3 Methodological approach for designing a local metabolic energy system

The proposed method for building a local metabolic energy system is based on forming an energy community that can arise from the collaborative dynamics among users within a given local system. Each energy community has specific characteristics, but all share the same goal: to self-produce and provide affordable renewable energy to its members.

The fundamental principles of this approach lie in the decentralisation and localisation of energy production. This is made possible through the active involvement of citizens, businesses, corporations, and other regional stakeholders, who collectively participate in the production, consumption, and exchange of energy (Guetlein and Schleich, 2023).

Indeed, as shown in the literature, citizen participation influences the success of local energy communities, where cooperative management is a crucial element for energy efficiency and sustainability (Neves et al., 2024). This approach suggests that energy-efficient systems should be designed based on community acceptance, tailored to local energy resources, and proportionate to the landscape and territorial context. The goal is to prevent large-scale projects that may have considerable impacts, as the community must accept and manage the metabolic cycle of production, consumption, and waste.

Based on the above, the path of an energy-metabolic project arises through the construction of a structured analytical framework, primarily focused on exploring potential local energy as it relates to heritage, environment, and landscape, articulated in:

- General framing of the area;
- Development of a state of affairs of renewable energy sources;
- Analysis of existing landscape and urban planning constraints;
- Definition of potential renewable energies that can be installed;
- Analysis of spatial and architectural heritage;
- Definition of local energy-metabolic potentials and options.

Once the analysis framework is finalized, we need to evaluate viable energy-metabolic options using assessment tools and indicators that inform design choices and actions. In this context, we propose utilizing LCA.

Based on the local energy demand framework and the area's potential, we evaluate alternative energy production and efficiency systems to optimize territorial energy resources and formulate a project hypothesis.

2.4 Life Cycle Assessment

Life Cycle Assessment (LCA) is a method for assessing and quantifying energy and environmental loads, as well as the potential impacts associated with a product, process, or activity throughout its life cycle, from raw material acquisition to end of life ("cradle to grave") (ISO, 2006). The relevance of this technique primarily lies in its innovative approach to evaluating all stages of a production process as related and dependent.

Among the tools that have emerged for industrial systems analysis, LCA has assumed a prominent role and is expanding rapidly both nationally and internationally.

Internationally, the LCA methodology is governed by the ISO 14040 series of standards, under which a life cycle assessment study involves defining the objective and scope of the analysis (ISO 14040), compiling an inventory of the inputs and outputs of a given system (ISO 14041), assessing the potential environmental impact related to those inputs and outputs (ISO 14042), and finally interpreting the results (ISO 14043).

At the European level, the strategic importance of adopting LCA methodology as a fundamental and scientifically appropriate tool for identifying significant environmental aspects is clearly expressed in Green Paper COM(2001) 68 final and COM(2003) 302 final on Integrated Product Policy. It is also suggested, if only indirectly, in the European Regulations: EMAS (Reg. 1221/2009) and Ecolabel (Reg. 66/2010).

LCA, for that matter, is a key support for developing environmental labelling schemes: in defining the environmental reference criteria for a given product group (type I eco-labels: Ecolabel), or as the primary tool for obtaining an Environmental Product Declaration: EPD (type III eco-label).

Its applications are potentially limitless: product and process development; environmental marketing; strategic planning; and public policy implementation.

However, detailed LCA studies can be costly and complex, requiring extensive environmental data and knowledge of methods and tools. Therefore, "simplified LCA" tools are being developed for quick life cycle verification of products, accessible even to those lacking the necessary skills and resources for full study.

Additionally, reliable data is crucial for the success of an LCA study. Efforts in the international and European arena aim to enhance access, availability, and open exchange of LCA data via public, protected, compatible, transparent, and accredited databases.

Simplified LCA builds on the traditional detailed LCA framework by evaluating the life cycle impacts of a product while also streamlining the analysis of those impacts.

For example, in contrast to a full LCA, the simplified version might utilize more secondary data (sourced from international databases) while reducing the number of primary data points (gathered directly from the farm). It might consider simplifying or omitting the analysis for certain product life stages.

Life Cycle Assessment (LCA) is a standardized methodology for evaluating the environmental impacts of a product, process, or service throughout its life cycle. Its mathematical formalization is based on mass, energy, and emission balance models, following a set of fundamental equations.

Mathematical formalization of LCA

As previously outlined, Life Cycle Assessment (LCA) involves four stages: *i*) defining objectives and scope; *ii*) conducting inventory analysis; *iii*) assessing impacts; and *iv*) interpreting results (Figure 1) (ISO, 2006). These stages are executed using mathematical equations that detail the material and energy flow within the system being analyzed, along with its environmental impact.

The very first stage involves defining the purpose and boundaries of the study, followed by identifying the product system and its intended function, as well as the environmental impacts and other factors to be evaluated (Baumann and Tillman, 2004).

In the inventory phase (LCI), inputs and outputs are quantified for each stage of the life cycle, starting from the extraction of raw materials to the end of life. This stage can be formally represented through the equation:

$$I_j = \sum_{i=1}^{n} S_{ij} \bullet f_i \quad (1)$$

where:
I_j= output flux j (usually CO_2 emitted);
S_{ij}= emission coefficient, resource consumption of process unit *i*;

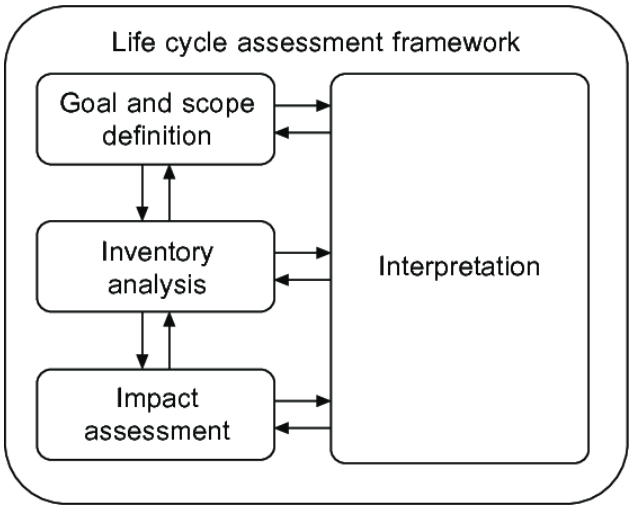

Figure 1. LCA phases, extracted from EN ISO 14040:2006 standard.

f_i= process flow for activity *i*.

Inventory is typically represented in matrix form; thus, a model is established that can analyze flows and express them succinctly. The matrix is defined by the following relationship (fundamental equation):

$$I=S \bullet f \quad (2)$$

in which:
I= vector of emission/output flows (e.g., CO_2; SO_2; NO_2);
S= technology matrix of emission coefficients;
f= vector of process flows.

At the end of the inventory stage, the environmental impacts associated with each category (LCIA) are characterized. During this stage, each elementary flow calculated previously is multiplied by a characterization factor (CF), which is defined using matrix notation as follows:

$$E=C\ I \quad (3)$$

in which:
E= vector of environmental impacts for each category *k* (e.g., global warming)
C= matrix of characterization factors (conversion of *j* flows to *k* impact units)
I= vector of emission flows resulting from the LCI

Finally, to relate the different impacts obtained, the following are applied: *i*) normalization; *ii*) weighting.

Normalization is represented by the formula:

$$N_k = \frac{E_k}{E_k^{ref}} \tag{4}$$

where:
N_k= normalized value of k
E_k^{ref} = reference value
E_k= environmental impact by category k

In the end, the weighting process assigns relative weight, W_k , to the different impacts. This leads to an overall total impact value represented by the following formula:

$$T = \sum_{k=1}^{p} W_k \bullet N_k \tag{5}$$

where:
T= total environmental impact value
W_k= weight assigned

3. METHODOLOGICAL PROPOSAL: THE CASE STUDY EXPERIMENT, A METABOLIC PROJECT FOR THE MONDEGGI ESTATE IN THE MUNICIPALITY OF BAGNO A RIPOLI

3.1 Spatial framework

The model proposed by this research was tested within the Mondeggi Estate, located southeast of Bagno a Ripoli in the Metropolitan City of Florence. The site lies south of the Antella hamlet, along the provincial road connecting Grassina to Figline Valdarno.

Situated approximately 8 km from Florence and just a few kilometers from the Firenze Sud highway exit, the estate is embedded in the hilly landscape of Bagno a Ripoli, an area that combines agricultural predominance – primarily olive cultivation – with a historical layering of rural and urban settlements of significant cultural and architectural value.

This area forms part of the so-called "Florentine landscape," characterized by a dense infrastructural network of minor roads and a rich architectural heritage, including villas, religious buildings, and tabernacles. Despite its historic rural identity, the area has undergone progressive transformations, revealing clear signs of broader "urbanization of the countryside". In particular, the valley floor of the Ema stream has experienced major landscape changes due to the development of the Scolivigne artisan district, which has significantly altered its rural character.

While the anthropogenic presence is long-established, recent decades have seen an intensification of residential construction with distinctly urban traits – such as the subdivision and renovation of former farm properties, the emergence of newly built villas, and the introduction of non-native vegetation in green spaces (Magnaghi et al., 2013; Bolognesi, 2018).

The goal of establishing a metabolic and circular energy system in the Mondeggi area begins with identifying a clearly defined territorial unit. This unit encompasses the estate itself and the surrounding zones of energy relevance, representing a potential energy community.

The study covers 340 hectares, comprising 170 hectares of the estate and an additional 170 hectares nearby. Over half of this area is agricultural land, featuring classic Tuscan crops such as vineyards, olive groves, orchards, and arable fields.

Another important portion of the area is occupied by deciduous and coniferous forests, which greatly enhance the area's natural beauty.

Thirteen percent of the area is sealed: within the estate, we find the villas and farm buildings; to the north is the Lapeggi villa farm complex, to the southwest is the Scolivigne industrial area, and to the south is the Capannuccia residential complex.

The presence of the Ema stream is important, as it naturally marks the border with the municipality of Impruneta.

The built-up areas in the region can be classified as farm-historical (43 percent), industrial-commercial (40 percent), and residential (17 percent).

3.2 The development of a metabolic energy scenario

3.2.1 Analysis of the research scope

The goal of designing a metabolic and circular energy system on Mondeggi's territory starts with defining a specific area that extends beyond the current boundary of the Estate, including regions of significant energy interest (Figure 2).

Establishing a status quo on current renewable energy production in the study area defines the project's starting point.

The Gestore Servizi Energetici (GSE), through the photovoltaic and solar plant census portal Atlasole, identifies six photovoltaic plants in the area capable of producing approximately 22 kW of power.

The limited presence of plants represents one of the area's weaknesses. It defines a key objective of the project: to establish a circular metabolic energy system, specifically to enhance the installation of renewable energy production plants through careful and precautionary operations that we will explore as the study progresses.

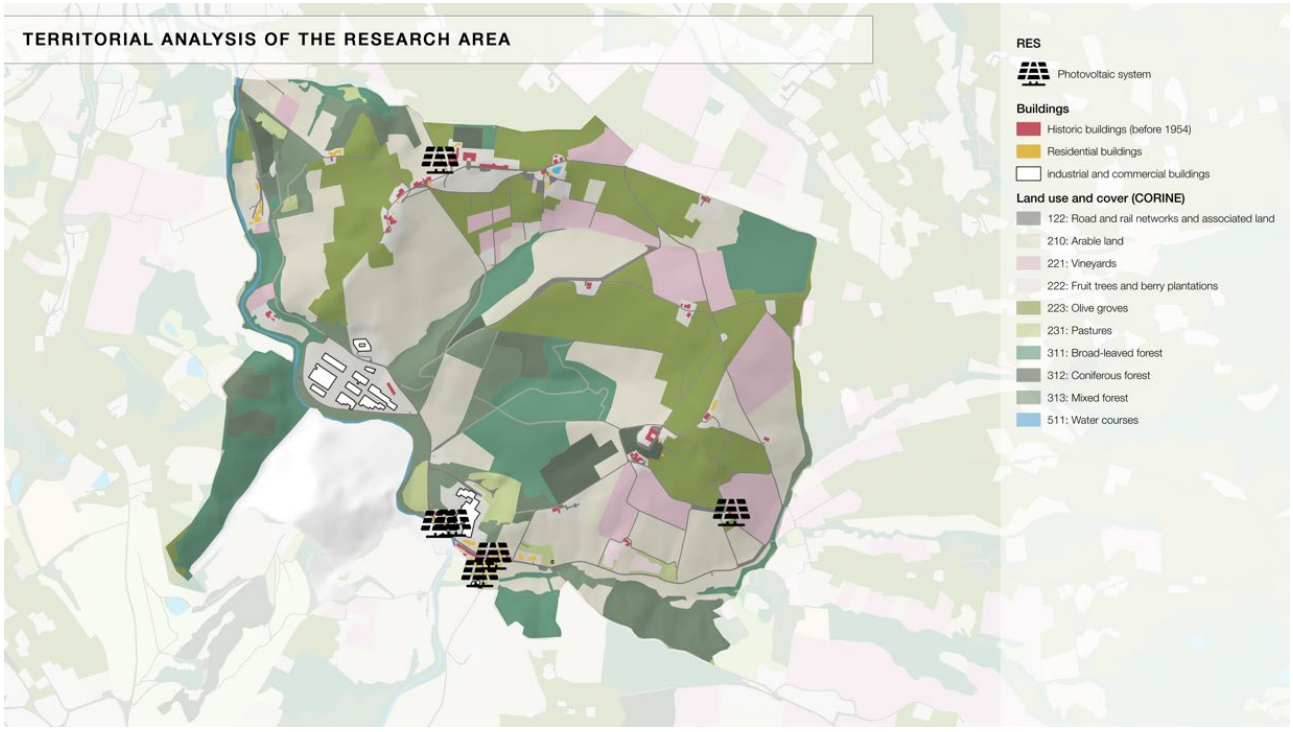

Figure 2. Territorial analysis of the research area.

The development of a summary analysis of the various constraints on the study area is most important for landscape and environmental values (Figure 3).

In line with national and regional legislation and the guidelines outlined in the regional spatial plan regarding the landscape plan (PIT-PPR), the areas under constraints have been identified using geographical data from the Tuscany Region's geo-portal.

After an initial analysis of the current state's territorial and constraining framework, the research continues by addressing the project approach and constructing a series of specific analyses that will define the area's energy potential.

3.2.2 Study of energy potential

The study and research regarding the Mondeggi area's wind energy potential rely on sources from the LaMMA Consortium's "WindGis" portals and the Gestore Servizi Energetici (GSE) "atlaeolico".

The average annual wind speed, a simple yet indispensable datum, was chosen as the indicator to define the area's wind potential.

The average annual wind speed is crucial for defining the potential energy producibility of a site, as it is proportional to the cube of the wind speed. Therefore, the average value of that speed allows for a rough estimate. However, arriving at an accurate value for producibility also requires considering the distribution of wind speeds, since winds of above-average speed contribute much more to producibility than those of below-average speed, as well as turbulence, which refers to rapid variations in wind speed. These variations can alter the normal flow of the wind, diminishing energy and significantly decreasing productivity. Average wind speed is typically calculated over a 12-month period to account for slow seasonal fluctuations. In fact, the average wind speed measured in any single year deviates from the average wind speed over 20 years by only about 5 percent.

Let us assume that electricity generated by wind power is produced where there is an average wind speed above 5 m/s and where a wind turbine can operate for more than 1,500 hours per year. As a rough estimate, with a properly installed micro-wind power plant at a site with an average annual wind speed between 5 and 6 m/s, between 1,000 and 1,800 kWh per year can be generated for each kW of rated turbine power. Thus, for a plant of only 5 kW, this means a minimum of 5,000 kWh per year (5 kW x 1,000 kWh) and a maximum of 9,000 kWh. By feeding the energy produced into the

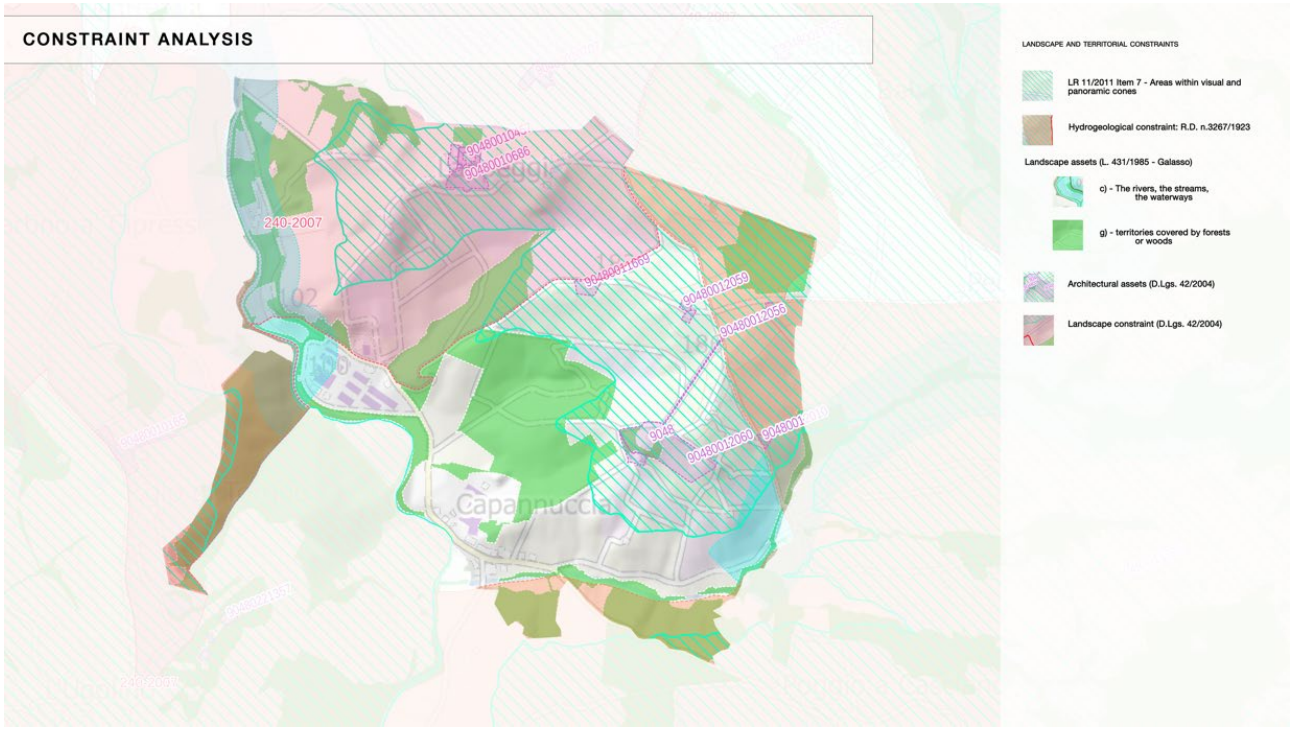

Figure 3. Constraint analysis.

grid, thanks to the government incentive of €0.30/kWh given by the "All-inclusive Tariff", this results in an annual income of a minimum of (0.30 x 5,000 =) €1,500 and a maximum of €2,700. If the micro-wind power plant is larger, for example, based on a 20 kW turbine, the minimum annual production can be estimated at 20,000 kWh and the maximum at 36,000 kWh, values that correspond in practice to an annual revenue of between € 6,000 and € 11,000.

In conclusion, Mondeggi Estate's low wind speed, under 5 m/s, which is below the minimum requirement for installing a micro-wind power plant, eliminates wind power as a feasible technology for the energy project (Figure 4a).

The presence of forests in the study area allows for sustainable estimation of biomass withdrawal for fuel in electricity and heat production.

The analysis started by evaluating factors including forest type, constraints assessment, morphogenetic analysis of the region, and forest accessibility review.

Considering the favorable outcome of the analysis and the fact that we are situated in a well-accessible hilly region where the majority of the forested areas are not subject to significant constraints, the study concentrated on estimating the biomass that could potentially be harvested in the area (Figure 4b).

The sustainable drawdown calculation was processed using GIS software in accordance with methods defined in the Tuscany Region.

The calculation starts by employing the Corine Land Cover codes for forest areas, each linked to specific accretion rates by species (m^3/ha). These rates are then multiplied by the area in hectares of each forest polygon to determine the annual increment (m^3/year). This figure is subsequently multiplied by the density associated with each species (kg/m^3) to compute the total increment weight. From this, we extract the percentage of residual biomass, yielding the potentially harvestable biomass (t/ha) available for energy production as fuel.

The substantial energy potential of the subsoil, characterized by its inexhaustibility and complete renewability, can be harnessed to cool buildings.

Starting at a depth of 10 meters, the ground temperature remains nearly constant throughout the year, unaffected by thermal exchanges with the surface or daily and seasonal temperature variations.

At a depth of 10 meters, the average geothermal gradient increases by approximately 3°C for every additional 100 meters. Between depths of 100 and 150 meters, ground temperatures generally range from 13°C to 17°C. Utilizing low-enthalpy geothermal systems makes it feasible to transfer heat between the subsurface and indoor

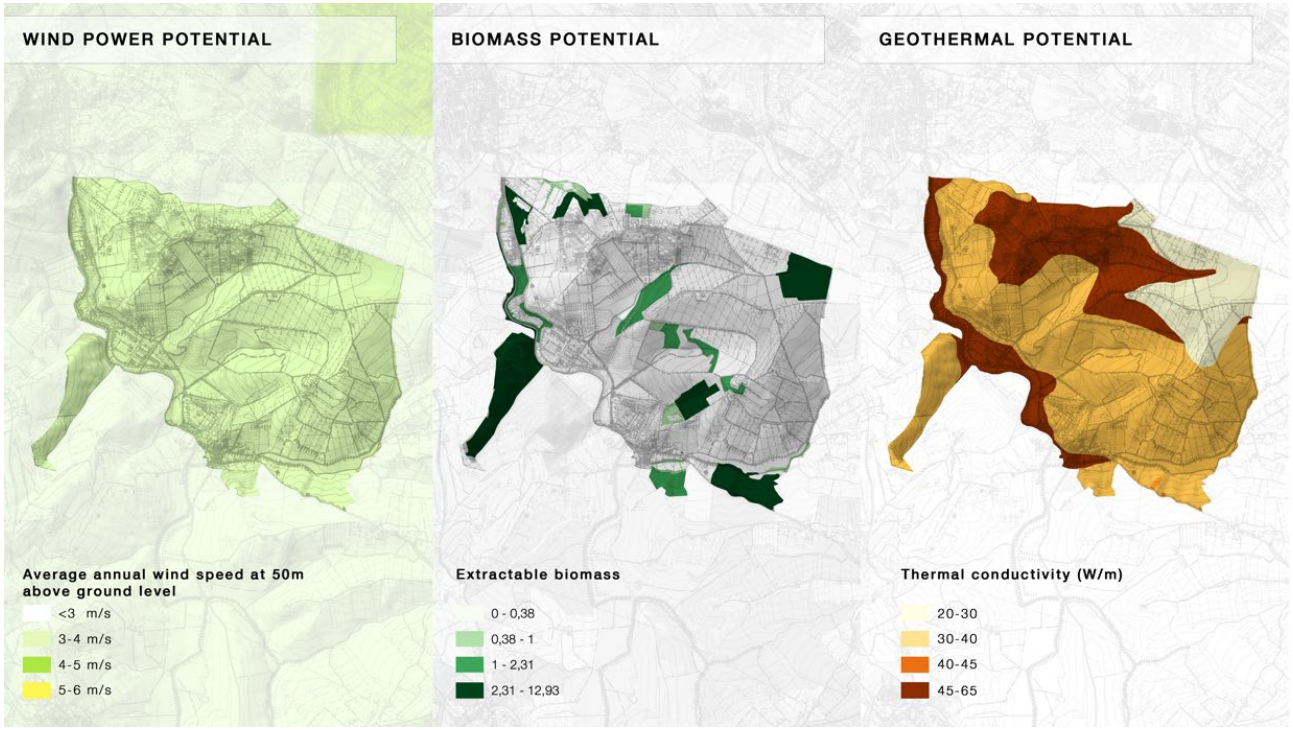

Figure 4. From left to right: (a) Wind potential; (b) Biomass potential; (c) Geothermal potential.

environments that necessitate heating or cooling, thereby assisting in the maintenance of stable indoor temperatures throughout the year.

The systems that move heat between the underground and living spaces utilize a liquid circulating through geothermal probes, a heat pump, and a "low temperature" heat distribution system (such as underfloor heating, radiant panels, and vents) as the medium.

In the Mondeggi energy system project, we identified the optimal locations for geothermal plant installations based primarily on the thermal conductivity of the underlying rocks (Figure 4c). Areas with higher heat transfer capacity indicate greater plant efficiency (geothermal yield) and allow for a rough estimation of the heat that can be extracted from each meter of buried probe.

However, the application of low-enthalpy geothermal technology depends on several variables that influence its deployment:

- Particularly in vertically developed systems (probes that penetrate deep into the subsurface rather than expanding horizontally), drilling into the ground may intercept the water table and contaminate it with pollutants
- Excavation runs the risk of connecting surface aquifers with deep aquifers, increasing the danger of contaminating the latter
- Slope dynamics should be considered because landslide movements could damage the plant.

Consequently, to determine the feasibility of constructing a plant, it is imperative to conduct comprehensive investigations to ascertain the soil stratigraphy and aquifer trends in a timely manner.

The subsurface's geological and hydrogeological parameters determine the geothermal system's efficiency. For this reason, it is difficult to calculate the exact amount of energy that can be obtained from low-enthalpy geothermal technology: the potential energy yield of this type of solution is infinite, since the Earth constitutes an inexhaustible reservoir of energy that is always available and could theoretically meet the air conditioning needs of any building (Bernetti et al., 2009).

3.2.3 Examination of territorial resources

Spatial heritage analysis gathers, outlines, and illustrates the existing spatial assets constituting the territory's identity.

Territorial heritage refers to the enduring structures created by the co-evolution of the natural environment and human settlements, the value of which is acknowledged for present and future generations. Recognizing

this value necessitates ensuring the existence of territorial heritage as a resource for community wealth production (Battisti and Pisano, 2022; Tuscany Region, 2015).

The constituent elements of the territorial heritage, their interrelationships, and their perception by the populations express the landscape identity of Tuscany (Article 3 L.R. 65/2014). Therefore, the Region promotes and guarantees the reproduction of territorial heritage as a common asset that constitutes the regional collective identity and serves as a resource for producing wealth for the community.

The mapping of territorial heritage follows the guidelines defined by the Territorial Address Plan (PIT) and the Landscape Plan (PPR) of the Tuscany Region.

The Estate's significant historical importance, which still allows us to observe the foundational structure of the Tuscan villa farm, makes Mondeggi one of the most valuable areas in the Metropolitan City.

The study area exhibits significant heritage elements, including the villa farm's foundational structure, the agricultural land's layout, and the presence of linear features such as dry-stone walls, irrigation canals, hedges, and rows that preserve the character of the Tuscan landscape (Figure 5).

The patrimonial analysis is crucial for defining project ideas by evaluating the area's long-term structure and outlining innovative actions, such as creating an energy cycle with renewable sources while respecting the area's historical character (Gross, 2007). The choice of processes to enhance the energy independence of the area relies heavily on compliance with the heritage criteria defined by the area's urban and landscape planning instruments.

Therefore, the next step involves identifying the potential energy resources that can be used in compliance with the landscape, territorial, and environmental protection criteria.

3.3 The project

3.3.1 Energy potential and energy requirements

The choice of potential energy resources in the area arises from the analytical framework that has enabled us to identify, as noted above, through detailed studies, the most suitable options that respect the landscape and environment of the study area.

The spatial elements that could be exploited are (Figure 6):

– Residential buildings: roofs of civil buildings not subject to constraints can be used as support for photovoltaic panels.

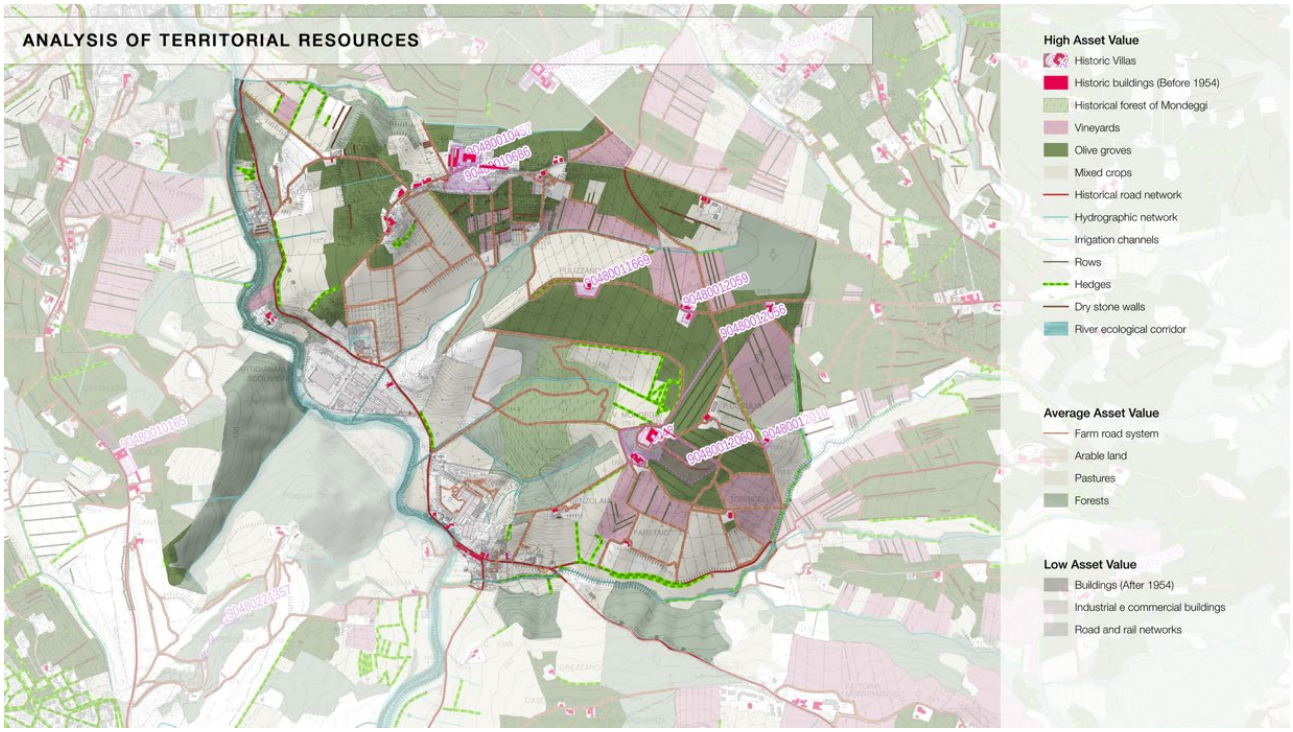

Figure 5. Analysis of territorial resources.

– Industrial and commercial buildings: industrial and commercial areas are the most suitable locations for installing various types of photovoltaic systems.
– Forested areas: unrestricted forested regions can support sustainable biomass harvesting for renewable energy fuel production.
– Tree crops such as vines, olive trees, orchards, and various crop areas can provide biomass from their pruning and waste for alternative energy production.

Estimating the energy needs of the study area is a key step in developing a metabolic energy project.

The final calculation determines the energy that will be generated by the facilities proposed in the project to enhance the area's energy self-sufficiency (Figure 7).

The process begins by calculating the population of the study area. For the Mondeggi Estate, the population figures stem from the project "Mondeggi: social, cultural and agricultural regeneration for a sustainable metropolitan city", which projects the potential residents that could occupy the site following redevelopment, as Mondeggi currently lacks officially counted inhabitants. In contrast, population data for other areas within the larger region were gathered from the 2022 ISTAT census, based on the 2021 findings. The total estimated population is 660 inhabitants.

The estimation utilizes various energy coefficients, allowing for the assessment of the energy needs in the study area.

3.3.2 A local metabolic energy mix

The territorial analysis of Mondeggi Estate enabled us to understand the project area in detail and define the design actions.

Focusing on local energy needs, efforts were made to create various elements that enhance energy self-sufficiency and develop a circular metabolic energy system. Each element functions as a circular unit, generating energy or heat from various renewable energy sources (Figure 8).

The graphical synthesis utilising an ideogram will be correlated with an estimation of energy production that will be compared against the potential requirements of the area. Moreover, the proposals, even when represented individually, will possess the capacity to coexist within the territorial framework, thereby establishing a complex structure that can adequately address the energy demands of the inhabitants to the greatest extent possible.

The self-generation of renewable energy must also be supported by energy-saving actions and efficiency practices that can reduce current demand.

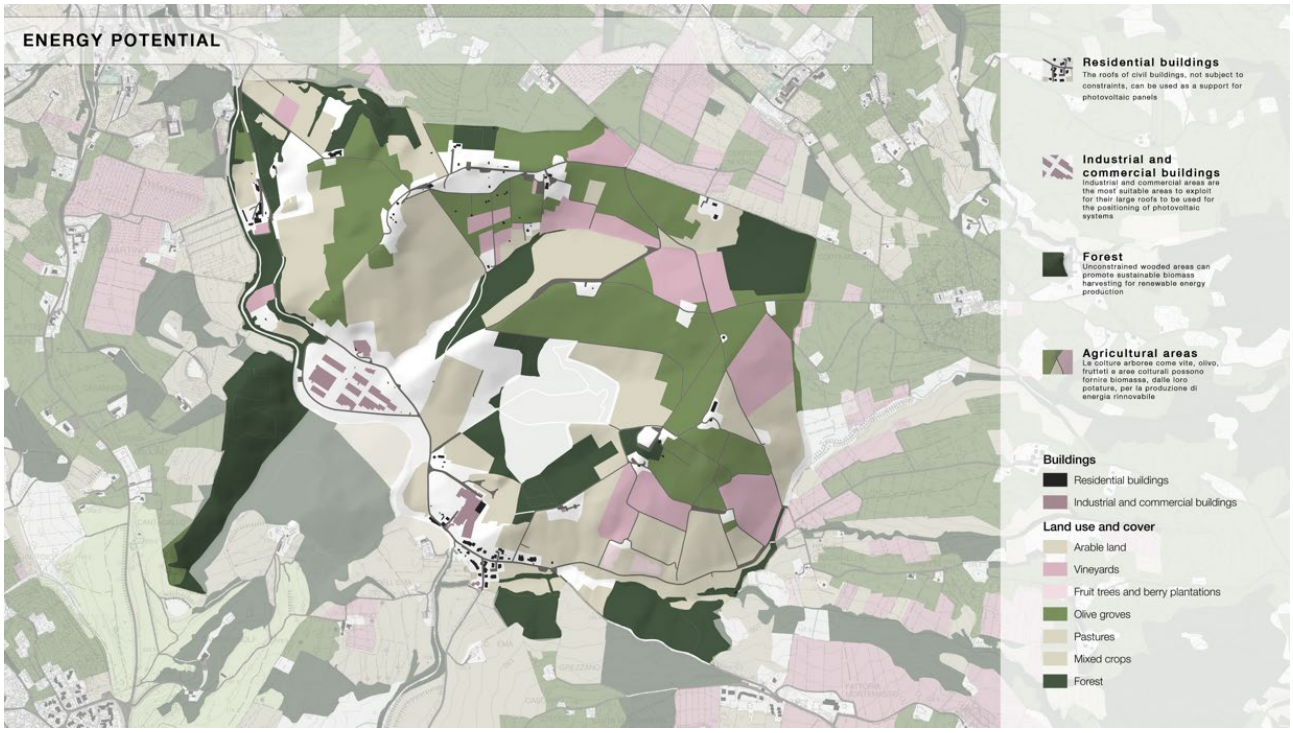

Figure 6. Energy potential.

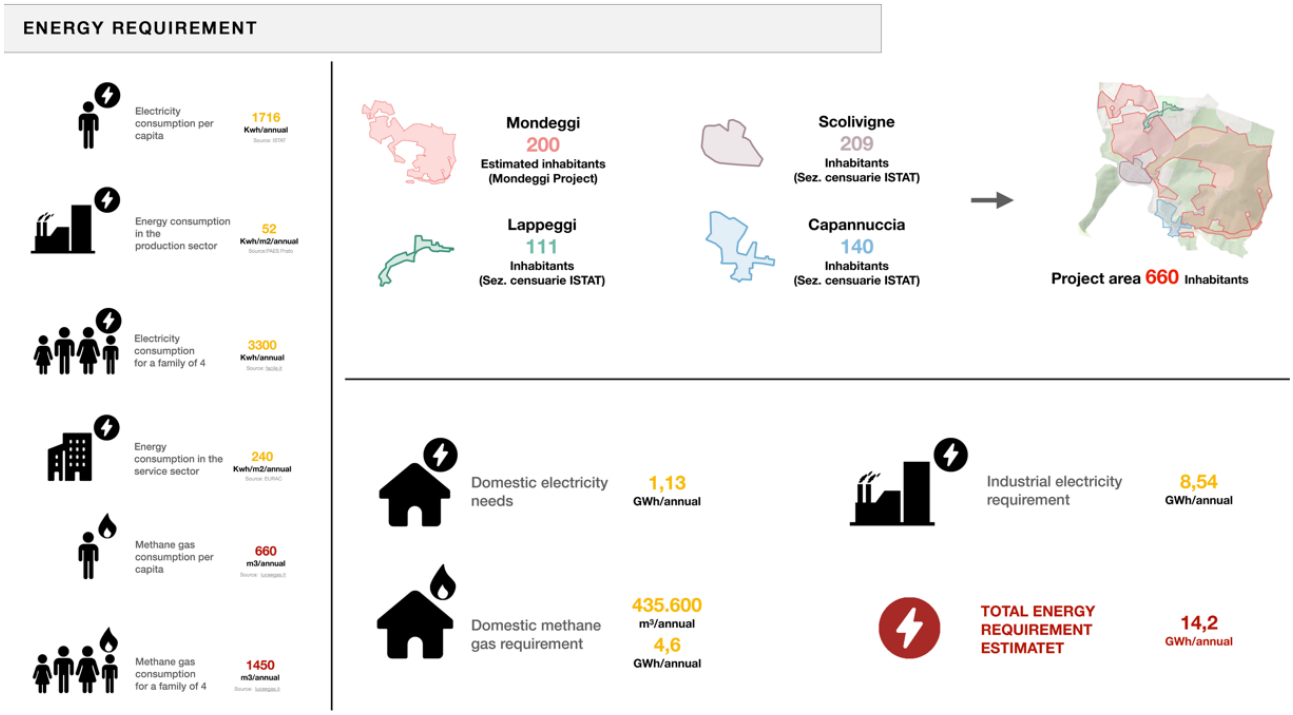

Figure 7. Energy requirements.

The first metabolic energy cycle was developed based on using the most renewable and sustainable energy source in existence: the sun. Photovoltaic systems represent one of the most widely used technologies for renewable energy production in the world, partly due to their easy structural installation.

The study assessed three options for the placement of photovoltaic systems in the designated area, selected primarily in accordance with the principles of sustainability while mitigating the increased land consumption associated with ground installations. These options include the installation of panels on residential, industrial, and commercial rooftops and the establishment of freestanding structures on impermeable surfaces, such as asphalt parking lots.

Placement choices were made considering various constraints, as shown in the appropriate table of the cognitive framework. The Mondeggi Estate features historic buildings where the installation of photovoltaic systems on roofs is restricted, except for a new shed designated for agricultural activities at the Cuculia farm.

Outside the boundary of the Estate, we find the placement of the facilities:

- in the Scolivigne artisanal area, with systems installed on roofs and in waterproofed parking lots using photovoltaic canopies
- in the Capannuccia building complex, located on commercial and residential roofs
- in the new parking lot located southwest of the Scolivigne area that supports the Estate, planned in the redevelopment project, which will feature photovoltaic carport shelters.

The calculation of the potential energy yield was performed using the formula:

$$\text{Productivity} = \text{solar rad. (kWh/m}^2\text{)} * \text{useful sup. (m}^2\text{)} * \text{max. efficiency} \quad (6)$$

where:
Municipal solar radiation in Bagno a Ripoli: 1,453 kWh/m^2 annually;
Useful panel area: varies depending on the type of roofing (36% for flat roofs, 60% for pitched roofs);
Maximum photovoltaic panel efficiency: 0.2.

The calculations indicate that the photovoltaic project has a total potential production of approximately 7.3 GWh per year.

Given the estimated energy demand of around 9.7 GWh/year, the project's implementation results in an energy deficit of 25 percent, or 2.4 GWh/year.

The second component defines a metabolic cycle for heat and hot water production. As analysed within the cognitive framework, the area includes several forested regions from which sustainable biomass withdrawals can be utilised as fuel.

This can be supplemented by establishing a collection loop for all woody agricultural waste from activities in the area. The supply chain was developed by designing a biomass and waste collection centre that subsequently converts all the collected material into wood chips, providing local residents with fuel for their domestic boilers. The calorific value of wood chips, 2.7 MWh/t, multiplied by the tons of wood chips produced from collecting local biomass and wood waste, makes it possible to produce 147,600 m^3/year of energy, corresponding to about 1.48 GWh/year. Given the estimated energy demand in the area of 435,600 m^3/year, the result of implementation is an energy deficit of 66 percent or 288,000 m^3/year.

The third study examines possible sites for the installation of low-enthalpy geothermal systems.

Extensive public facilities, like school buildings, recreation centers, and community spaces, often have a high energy demand, particularly for air conditioning. This demand can be addressed by installing a low-enthalpy geothermal system.

The geothermal study identifies initial potential installation sites based on a comprehensive geothermal analysis within the analytical framework, alongside a search for strategic spatial locations. However, determining the appropriateness of constructing a plant necessitates precise investigations to understand the soil stratigraphy and aquifer trends in detail.

The selected points represent the primary and most energy-intensive public activities, both current and planned:

1. *Villa di Mondeggi*: the planned redevelopment will convert the historic villa into the estate's primary attraction. This approximately 3,000 m^2 structure will feature a potential low-enthalpy geothermal system, allowing for year-round air conditioning.
2. *Capannuccia* Preschool 'Catia Franci': Situated in the Capannuccia area, this building along Tizzano road, south of Mondeggi, spans approximately 500 m^2 and could implement a low-enthalpy geothermal system.
3. AIABA ONLUS Headquarters 'Aldo's House': One of the headquarters of the Italian Association for the Assistance of Autistic Children (AIABA) established in Florence in 1970, the facility is a historic country villa of about 600 m^2 that has been redeveloped to accommodate the independent living project for adults diagnosed with autism. It represents the last potential point of installation for a low-enthalpy geothermal system. By utilising a low-enthalpy geothermal system, the considerable initial installation cost, once amortised, will result in a considerable reduction or elimination of home heating expenses.

An estimate was made of the economic savings resulting from switching the heating system of the selected structures in the project from a gas boiler to a low-enthalpy geothermal system. It is estimated that the average gas consumption per square meter per year for heating a building with average insulation, without thermostats to regulate the temperature in individual rooms, and with a boiler less than 10 years old is 9 Sm^3/m^2/year. Knowing that the total area of buildings slated for installing a low-enthalpy geothermal system is 4,100 m^2, the total gas requirement for heating is about 36,900 Sm^3/year. Given that, as of November 2022 the cost of methane gas established by ARERA for those with a contract under the protection regime is € 1.05/Sm^3, the total cost of the requirement is about € 38,700, which can be entirely saved with a low-enthalpy geothermal plant.

The installation of renewable energy production systems must be supported by energy efficiency works and cost-saving practices.

Energy efficiency is represented by the value of a building's energy class, which indicates how the building has been constructed concerning insulation, technological systems, and, most importantly, the interventions needed to optimise the building's energy performance. The fundamental goal of energy efficiency is not to give up consumption but to consume more effectively and experience positive effects on the amount of energy used. According to the depiction, improving efficiency helps transition a building from a lower to a higher class, significantly reducing energy consumption.

Through a broad analysis, which involved observing the buildings in the study area and calculating inversely from the residential areas, it was estimated that the energy classes present in the study area are class F and class E. These classes are very energy-intensive and consequently inefficient.

The scenario envisions enhancements in efficiency for all residential structures within the region by upgrading them to energy class A, which facilitates a reduction of approximately 50 percent in total energy demand.

3.3.3 Metabolic energy indicators

A final metabolic energy scenario was developed through an evaluation process that utilised several indicators, enabling the definition and summary of the environmental and economic impacts of the design choices (Figure 9) (Battisti, 2022). The development of a territorial energy mix, composed of various production components that enhance the area's potential, requires significant investment, which must be evaluated to identify the best opportunities and the feasibility of implementation.

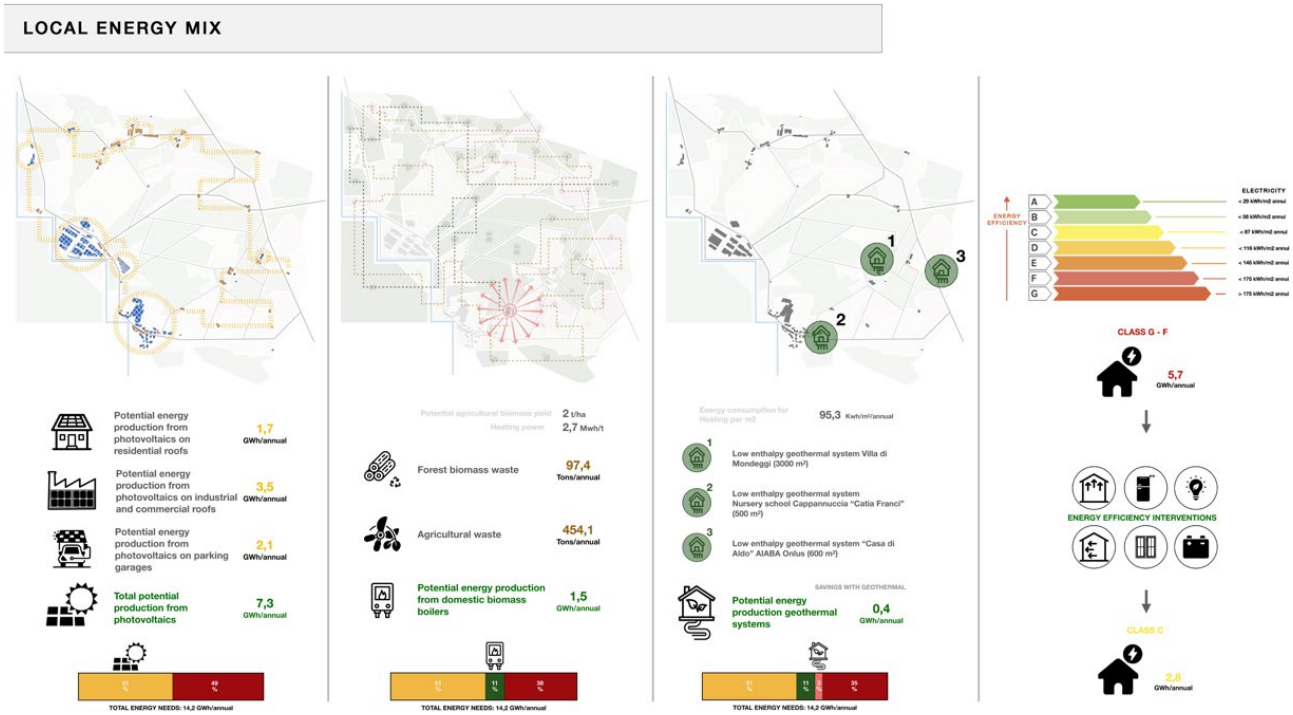

Figure 8. Local energy mix.

In addition, installing renewable energy systems for self-consumption can reduce annual energy costs to zero in cases of complete self-sufficiency. The design of an energy metabolic system based on local renewable energy production enables substantial reductions in energy costs.

A key metric for the project is the payback period, a commonly used method for determining the time required to recover the invested capital in purchasing an input through the net cash flows it generates. Among alternative investments, the one with a shorter "payback period" will be chosen, as from that point onward, the capital asset will contribute to gross profits.

Finally, avoided CO_2 emissions serve as an indicator of environmental benefits, calculated by multiplying the electricity output from each renewable source by the average specific CO_2 emissions derived from fossil thermoelectric generation that would otherwise be necessary. The environmental benefits of adopting renewable systems are proportional to the amount of energy produced, assuming it replaces energy supplied by conventional sources.

3.4 The metabolic energy scenario

The final stage of the research involved creating a summary paper that visually encapsulates the journey undertaken (Figure 10). The analysis of metabolism and the study of energy systems were effectively directed toward developing an energy project within a specified spatial region, which was examined, designed, and evaluated according to the principles and models of urban metabolism. The concluding scenario emerges from formulating a local energy mix that considers the identified energy potential within the analytical framework and aims to enhance it by advancing sustainable energy recovery and production cycles.

The project was created with essential objectives and concerns in mind, such as respecting the environment and landscape, minimizing land consumption, choosing sustainable energy options, and sizing renewable production facilities appropriately. Project development starts by estimating the area's energy needs using per capita consumption coefficients based on the current and future population.

The study area is a linear metabolic system capable of consuming 14.2 GWh/year of energy produced entirely by large national plants, necessitating an annual expenditure of approximately 5 million euros. Furthermore, if this energy is generated solely from conventional sources, it will produce 9.3 million kilograms of gaseous emissions.

The territorial analytical framework defined the area's energy potential based on regional environmental

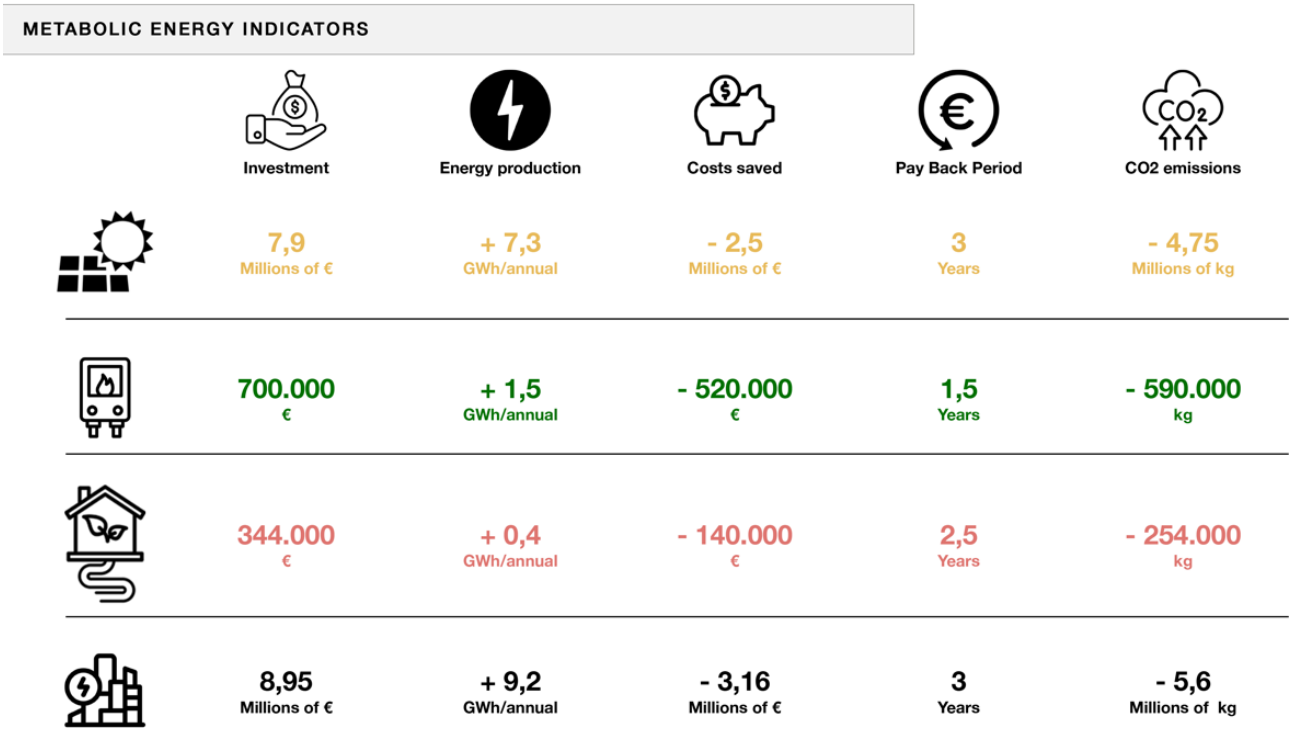

Figure 9. Metabolic energy indicators.

standards, leading to three initiatives: installing photovoltaic systems, recovering agricultural and forestry biomass for energy through domestic boilers, and proposing three low-enthalpy geothermal plants for energy-intensive activities.

The energy mix results from the simultaneous presence of these three energy production components in the area. This setup aims to harness the region's energy potential and could ideally generate up to 9.2 GWh/year.

The photovoltaic system represents the most productive component of the project, given the greater possibility of installation. It entails an estimated intervention of about 7.9 million euros, which would enable the installation of photovoltaic systems on any roof not subject to landscape or architectural constraints, as well as photovoltaic canopies on sealed soil. This setup could potentially produce a total of 7.3 GWh/year of electricity.

This intervention would lower current energy costs by 2.5 million euros, amortising the initial investment in approximately 3 years. Additionally, from an environmental perspective, the intervention would also have very positive effects, avoiding the emission of 4.75 million kilograms of carbon dioxide into the atmosphere due to the switch from conventional to alternative sources.

The region's extensive agricultural and forested areas generate approximately 550 tons of wood waste annually. Utilising this waste as fuel for domestic biomass boilers could produce 1.5 GWh of energy per year, potentially saving €520,000 in energy costs and preventing 590,000 kg of carbon dioxide emissions annually.

The energy mix is complemented by the planned installation of three low-enthalpy geothermal plants, which will be located in the three most energy-intensive public buildings. The estimated investment is around €340,000 and is expected to yield 0.4 GWh/year of clean energy, reducing energy costs by €140,000 and allowing for the initial investment to pay off in approximately 2.5 years, while also helping to decrease annual emissions by about 250,000 kg. Enhancing territorial energy potential as much as possible, while respecting landscape and sustainability canons, produced 9.2 GWh/year of energy compared to the 14.2 GWh potentially required by the territory, meeting about 65 percent of energy demand.

Nonetheless, as the article consistently emphasises, the advancement of a metabolic energy initiative cannot solely be confined to production; it must also be complemented by measures aimed at enhancing efficiency and implementing conservation actions.

As illustrated in the scenario, energy efficiency is integrated into the metabolic energy project, delineating the most utilised methodologies for a substantial advancement toward a significantly higher energy classification that would dramatically reduce a building's energy consumption. Ultimately, structural and opera-

tional modifications must be complemented by effective energy-saving practices. It is important to note that energy saving does not invariably result in enhanced efficiency; rather, it signifies a reduction in demand through the adoption of lifestyles and consumption patterns rooted in a more responsible utilisation of energy. Consequently, the objective of energy conservation is to minimise consumption.

Thanks to the energy efficiency initiatives and commendable savings practices mentioned earlier, the area must recover around 5 GWh/year of energy. This will help ensure it does not have to rely on the national electricity system and can achieve complete energy self-sufficiency. The goal is to meet all energy needs and reduce greenhouse gas emissions by utilising renewable energy produced locally from small plants, which align with landscape regulations, rather than constructing large facilities.

The metabolic energy project was developed around three pillars of sustainability, focusing on fostering positive environmental, social, and economic outcomes. The evaluation process highlighted a noticeable reduction in costs attributed to the transition to alternative energy sources, which significantly enhanced economic sustainability. Additionally, the production of alternative energy has led to a considerable drop in carbon dioxide emissions, aiding in climate change mitigation and addressing the global temperature rise as identified in both national and international regulations.

In conclusion, creating an energy community fosters community support, integrating into a broader community-building effort that encourages citizens to collaborate more and heightens their engagement in social activities.

4. EXPERIMENTATION AND RESULTS

4.1 Life Cycle Inventory (input data)

The simplified Life Cycle Assessment (LCA) calculation was conducted utilising the professional software One Click LCA Planetary, which possesses the capability to analyse the environmental impacts associated with a building system. This assessment evaluates five stages of the life cycle, commencing with the extraction of materials (A1), followed by transportation to the production site (A2), culminating at the end of the production process at the factory (A3), thereafter transporting to the construction site (A4), and concluding with the installation at the construction site (A5).

The initial section requests project input data, specifically highlighting three evident sections: *i*) Building

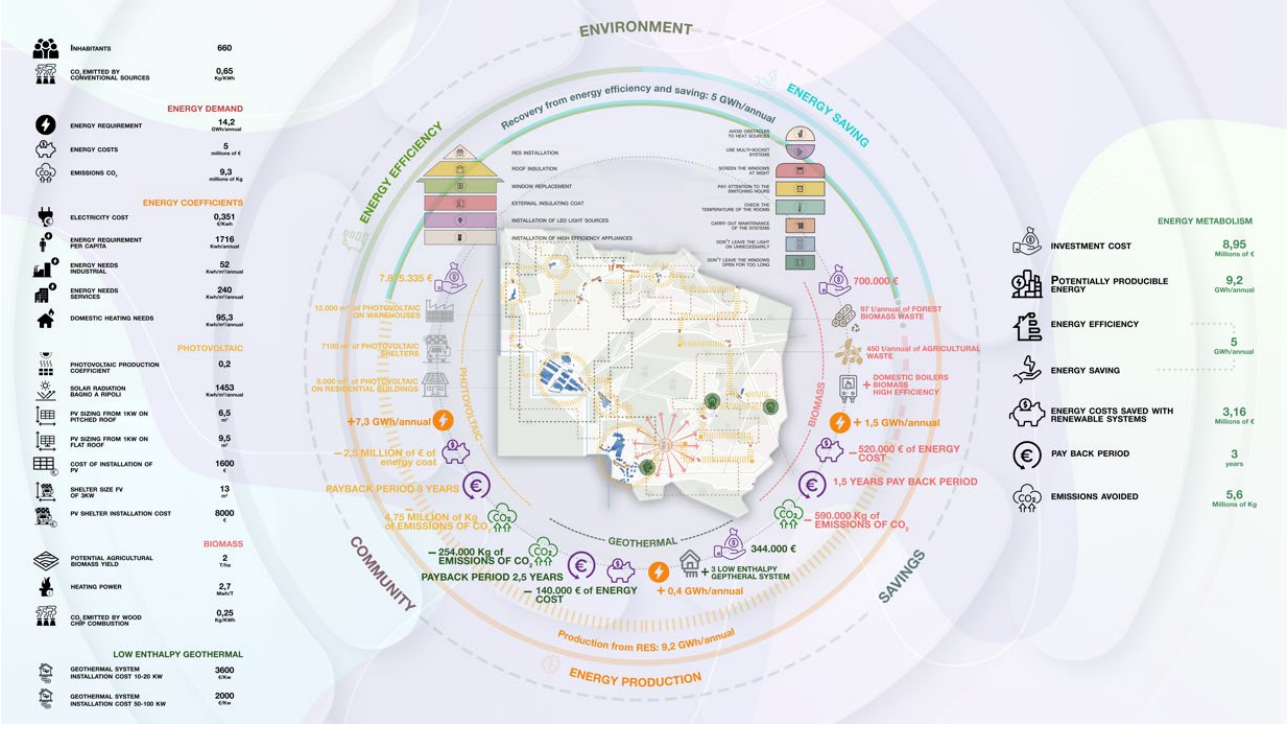

Figure 10. Summary diagram.

materials; *ii*) Construction site operations; *iii*) Area of construction.

As outlined in Section 2.4, a crucial aspect of the LCA involves creating an inventory of the materials utilised in the project (LCI). The initial section, "Building materials", presents the materials by functional groups: *i*) Foundations and substructures; *ii*) Vertical structures and facades; *iii*) Horizontal structures, including floors and roofs; and *iv*) Other structures and materials.

The details include the average AITEC 2022 cement present in all primary structures (pillars and floors), clay bricks (Clay Brick) utilised for vertical structures and interior walls, and solid wood panels (493 kg/m3) applied in fixtures and finishes. Each material specifies the following: quantity, unit of measure, average transport distance (km), transport type, and percentage of material lost or discarded (%). The input data is displayed in Figure 11.

The "Construction site operations" section outlines the various activities at construction sites, specifically focusing on the quantitative aspects of resource consumption related to construction activities, including electricity, fuel, biogas, and construction waste. For simplification, data on water usage or auxiliary materials have been excluded from the model.

Finally, the "Area of construction" section comprises the site data; the software mandates the input of the gross internal building area, including any basements, and exclusive of parking or vehicle circulation areas. Consequently, the area is calculated to be 98,000 m^2.

4.2 Emissions and environmental impact (output data)

Once the calculation is run correctly, the software returns a result of 19,054 tCO_2e, broken down into the following phases:

- Phases A1-A3: 17,997 tCO_2e
- Phase A4: 119 tCO_2e
- Phase A5: 938 tCO_2e

It is also of interest to analyse the figure referred to as the "social cost of carbon". Specifically, this figure represents the economic value of the damage attributable to those particular CO_2 emissions, totalling € 952,713 (Figure 12).

Additionally, the project's average carbon footprint is measured at 194 kgCO_2e/m^2 of gross usable area. The comparison below (Figure 13) with the "Carbon Heroes" benchmarks (classification A to G) shows that the project's carbon footprint places it in category B (188 to 255 kgCO_2e/m^2).

More specifically, the results suggest that phases A1-A3 have the highest emission contribution compared to the total. Examining the emission contribution by material within these phases, it is clear that cement is the primary contributor to CO_2 emissions, accounting for approximately 13,030 t CO_2e (72.4 percent of the cradle-to-gate A1-A3 impacts), followed by materials such as bricks (4,337 t CO_2e; 24.1 percent) and wood (630 t CO_2e; 3.5 percent), which have significantly lower

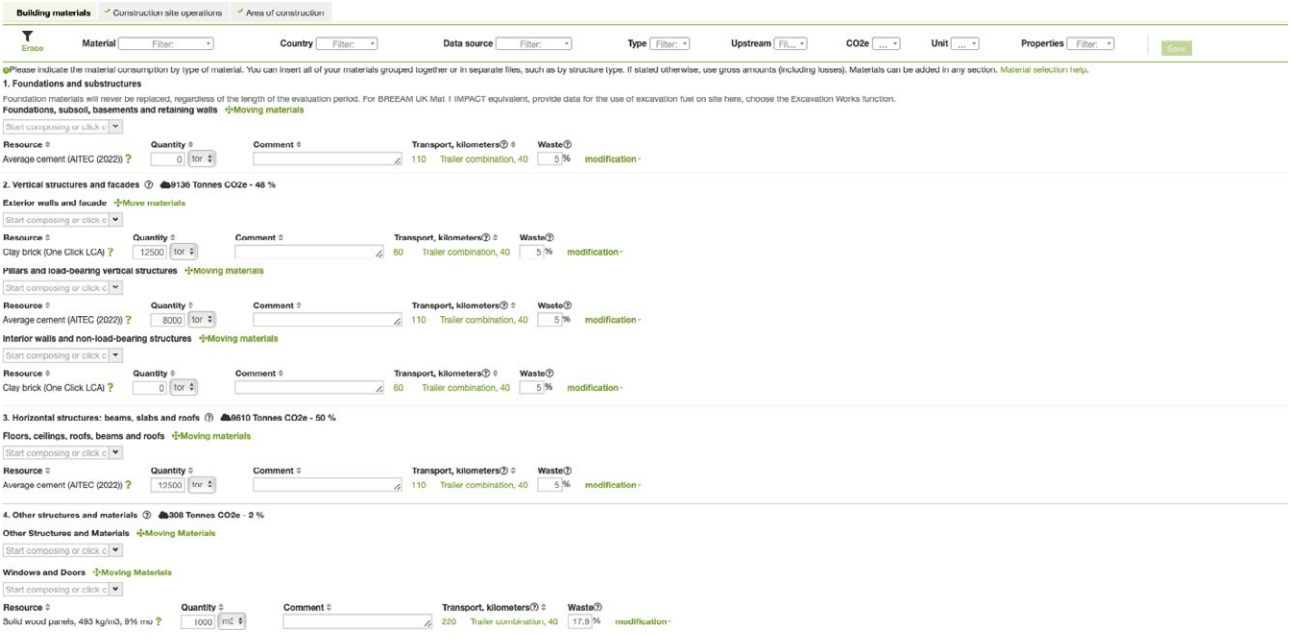

Figure 11. Material input data.

Figure 12. Total emissions.

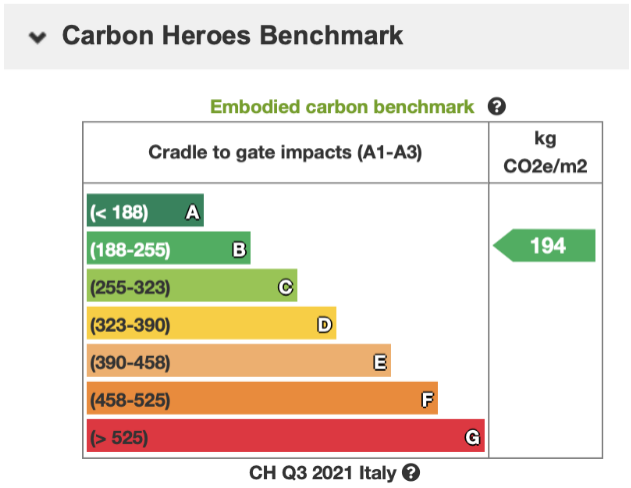

Figure 13. Benchmarks Carbon Heroes.

impacts than that of cement but remain notable relative to their mass (Figure 14).

The analysis is also organised by functional categories. Horizontal structures – including floors, ceilings, and roofs – are identified as the most impactful categories due to their use of concrete, which is the largest contributor to key CO_2 emissions. Although vertical structures also contribute to global warming, their impact is considerably lower than that of horizontal structures. These vertical categories primarily consist of bricks, a material that has a smaller carbon footprint compared to concrete. Figure 15 illustrates the impacts expressed in tCO_2e for the functional groups across different phases (A1-A5) and the materials that compose them.

The categories related to transportation (light blue) and construction activity (orange) have relatively less impact than the production phases. Below are graphs summarising the distribution of CO_2 emissions by stages and categories (Figure 16).

In the life-cycle phases, cement contributes 68.4 percent to total emissions, while bricks represent 22.8 percent, and wood has a 3.3 percent impact. Transportation (Phase A4) and site installation (Phase A5) have lower impacts, contributing 0.6 percent and 4.9 percent, respectively, of the total emissions.

Through the simplified LCA analysis conducted, it is possible to state that the Mondeggi project performs well compared to the average, placing in the B range according to the Carbon Heroes Benchmarks. There may be room for improvement by adopting more sustainable materials and optimising the construction and transportation phases. The use of energy-intensive materials such as concrete should be reduced in favour of more sustainable and circular solutions.

5. DISCUSSIONS AND CONCLUSIONS

The Mondeggi project constitutes a pivotal component of the Integrated Urban Plan Next regeneration: Florence 2026, appropriately funded by resources allocated under Law 233/21. This initiative seeks to facilitate the comprehensive enhancement of extensively deteriorated urban territories, encompassing areas within the municipalities of the Metropolitan City of Florence, through systematic urban regeneration and economic revitalisation efforts.

The most contributing materials (Global warming)

No.	Resource	Cradle to gate impacts (A1–A3)	Share of A1–A3
1.	Average cement, AITEC 2022	13,030 t CO_2e	72.4 %
2.	Clay brick	4,337 t CO_2e	24.1 %
3.	Solid wood panels, 493 kg/m³, 9% moisture content	630 t CO_2e	3.5 %
	Total A1-A3	**17,997 t CO_2e**	**100.0 %**

Figure 14. The most impactful materials.

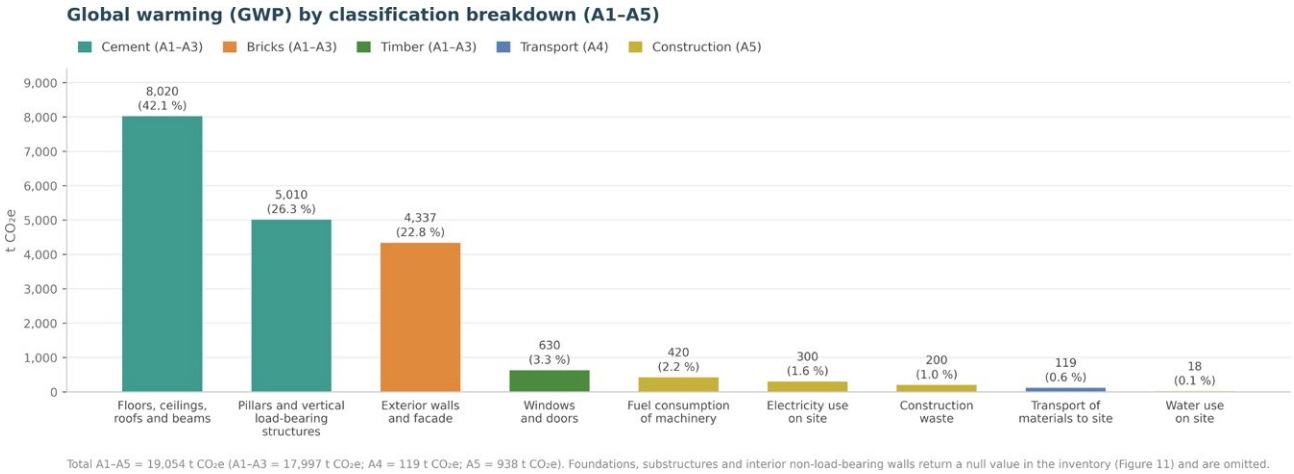

Figure 15. GWP classification by functional groups.

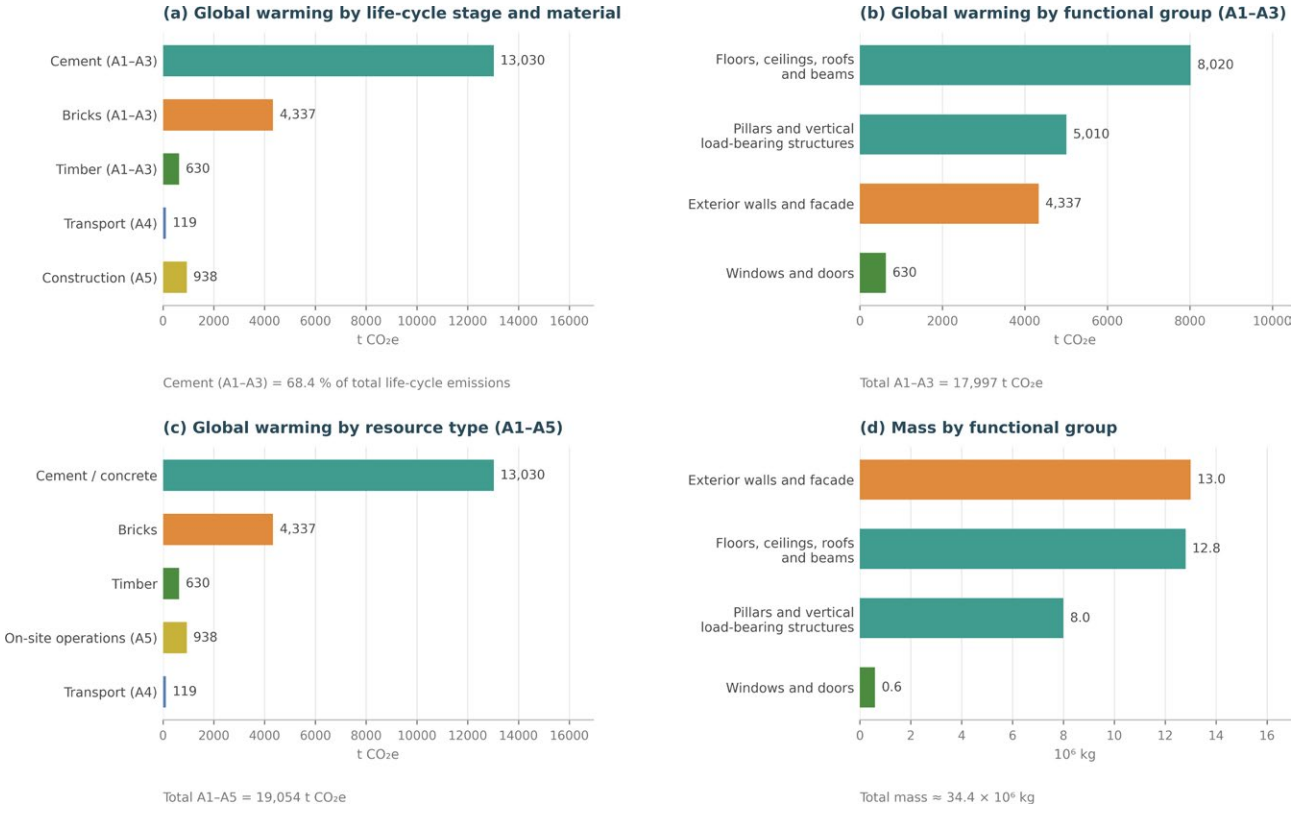

Figure 16. Analysis of GWP emissions by categories.

The objective of the project is to transform the Mondeggi Estate, situated amidst vineyards and olive groves at the confluence of the municipalities of Bagno a Ripoli, Impruneta, and Greve in Chianti, into a collaborative, innovative platform that promotes social inclusion for all generations. The articulated aim is to enhance the social and economic prospects of the current and future residents of the entire metropolitan territory, ensuring comprehensive respect for the environmental ecosystem and natural resources, with a particular emphasis on the youth (Biggeri et al., 2023).

Such a project, undoubtedly characterised by significant complexity and governed by a long-term strategic vision, derives its strength from the organisation of

a multifaceted and transparent system (Guarini et al., 2014; Guarini et al., 2017). This framework establishes a stable environment within which activities, functions, and programs can evolve over time, while also facilitating the expression of energy-environmental sustainability in a metabolic context.

Based on this framework, the research was conducted to delineate a sustainable model for implementation by specifying the conditions necessary to attain environmental and energy sustainability within the anticipated and proposed complex systems of the estate. To adequately address the multifaceted requirements of the intricate, heterogeneous, and energy-intensive meta-project, a meticulous analysis of all relevant elements was undertaken to convert them into design strategies.

The research findings illustrate the capacity to protect and preserve, over time, the natural and ecosystemic resources, while avoiding irreversible alterations. The relationship between the flows of resources (energy and water) that the Mondeggi Estate system absorbs and produces can be described as a zero balance. Upon the completion of eco-sustainable renovation and functionalisation interventions, the Mondeggi Estate will function as a complex organism, where the processes involved will include the absorption of energy, water, and raw materials, which, once "metabolized", will facilitate the operation of the Estate itself, particularly its agricultural component and the buildings encompassed within it that are subject to restoration or refunctionalization, until they eventually become waste and refuse. This approach is, in summary, one that has been embraced by numerous European administrations in recent years, promoting research from a metabolic and ecosystem perspective in the development of urban plans and projects both at the national level (e.g., foresight Future of Cities Project, UK; Government Office for Science, 2017) and at the local level (e.g., Genoa or Antwerp). Transitioning from linear production-consumption models to circular systems now appears to be imperative in order to mitigate the impacts of urban and peri-urban environments and achieve the environmental objectives outlined in the European agenda.

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Citation: Batoctoy, C. F. S. (2026). Effectiveness of the Community Household Level Coconut Processing Project (CHLCPP) in Bukidnon, Philippines. *Aestimum* 88: 111-122. doi: 10.36253/aestim-17288

Received: February 8, 2025

Accepted: September 10, 2025

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Effectiveness of the Community Household Level Coconut Processing Project (CHLCPP) in Bukidnon, Philippines

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Abstract. The Philippine government spends a lot of resources to aid the farming sector. Still, most of the farmers are considered economically poor. The study evaluated the effectiveness of the KAANIB Enterprise Development Project's coconut processing component by the Philippine Coconut Authority in Kibawe and Damulog, Bukidnon, 10 years after implementation. Using descriptive research and thematic analysis on 140 beneficiaries, it measured profitability changes through a paired sample t-test. Significant improvements were found in Return on Investment, Return on Asset, Return on Equity, Gross Profit Margin, and Net Profit Margin for both locations. The study highlights the need for a proper community needs assessment and comprehensive impact evaluation to address project setbacks. Findings support policy recommendations to help the agency better achieve its goals.

Keywords: effectiveness, KEDP, profitability.

1. INTRODUCTION

The Philippine economy has historically relied heavily on agriculture, which serves as a cultural and historical foundation that unites generations as well as a source of income for millions of people. Agriculture contributes 10% of the nation's GDP and employs roughly 23% of the labor force, making its role undeniable. Beyond the numbers, though, is a tale of resilience – one molded by Filipino farmers overcoming structural obstacles, erratic weather patterns, and changing market dynamics (Ichwandiani and Hassan, 2025).

The coconut is one of the country's natural resources. The Philippine coconut industry is characterized by a high incidence of poverty among small-scale coconut farmers (Seriño et al., 2021). The Philippines is the world's second-largest producer of coconuts and the biggest exporter of coconut products. Over the previous few decades, the industry has provided an average of 35% of the country's overall agricultural exports, and millions of Filipinos depend on it for their living and income. The coconut industry

is considered to be one of the pillars of the Philippine economy since it generates the majority of the country's agricultural exports (Philippine Coconut Authority, 2023).

According to Ndoen et al. (2018), a significant barrier for coconut growers is a lack of access to support services. They proposed that increasing the accessibility of support systems could boost agricultural production and income.

Coconut, a crucial crop and export in the Philippines, has not seen significant improvement in recent years due to controversies surrounding the coconut levy fund. President Duterte vetoed bills to support development initiatives and increase farmer income. However, the industry's positioning should be addressed, with continued expansion of coconut and fostering oil palm development as strategic paths. The industry is vital due to its presence in 69 provinces, vast coconut fields, high rural poverty, and potential for diversification. The coconut levy funds, which have been a court battle since 1986, offer a vast resource pool for industry growth. In 2021, coconut production increased by 1.9%, with Calabarzon being the leading producer, followed by Northern Mindanao and Davao Region (Ani and Castillo, 2019; Dy and Reyes, 2006; PSA, 2021).

The coconut industry is stuck in a wormhole of stagnating productivity and terrible poverty. The industry's access to resources is constrained. Nonetheless, this orphan child of Philippine agriculture has one of the highest development potentials because of greater productivity, diversification, and industry value addition. When correctly managed, it can aid in rural industrialization and job generation (Dy and Reyes, 2006).

The KAANIB Enterprise Development Project (KEDP) of the Philippine Coconut Authority (PCA) aims to develop and institutionalize coconut-based enterprises by utilizing an integrated resource-service convergence approach to solve food security, enhance income, and create jobs in small coconut farming communities. The implementation was based on enterprise development, with Community-Based Organizations (CBOs) or Micro, Small, and Medium Enterprises (MSMEs) as fundamental production units encouraged to achieve equitable development (Philippine Coconut Authority, 2018).

As reported by Balane (2013), according to a coordination meeting, the Matigsalug tribe in Bukidnon was eyeing coconut plantations for livelihood, and they were coordinating with the PCA. In addition, the author cited that despite the grants, coconut farmers had been stuck in poverty, and the tribe still struggles to use their resources to make ends meet. Additionally, there was a program of the PCA which grew out of the Maunlad na Niyugan Tugon sa Kahirapan Program that was introduced under EO 210 in February 2000, which seeks to raise farmer income and productivity from PhP 10,000.00 to PhP 100,000.00. It also aims to boost coconut production by conserving, replanting, and rehabilitating the palm population. Regrettably, this program has fallen short of its objectives (Dy and Reyes, 2006).

The Maunlad na Niyugan Tugon sa Kahirapan Program was also implemented by the PCA, similar to the KAANIB Enterprise Development Project (KEDP), which also seeks to increase farmer beneficiary's annual income. With that being said, it is relevant for the researcher to study the Community Household–Level Coconut Processing Project (CHLCPP) Component of the KAANIB Enterprise Development Project (KEDP) implemented in Kibawe, and Damulog, Bukidnon, to determine the effectiveness of the project for its beneficiaries.

According to Barret et. al. (2018) and Bayacag (2020), to analyze the contribution of a certain project to impact, it is necessary to establish causal links between the current operation and the changes it has on farmers' representations and practices and, on the other hand, its effects in economic, social, and environmental terms. Additionally, impact assessment is embedded in many national and international research rating systems. The Research Impact Pathway is used by most applications to track the inputs, activities, outputs, and outcomes of an invention or initiative to assess impact beyond scholarly contributions to an academic research field. Existing approaches emphasize easy-to-attribute hard impacts while ignoring a variety of soft impacts that are more difficult to attribute but are frequently a dominant part of the impact mix. (Fryirs et al., 2019).

The results of the study can be very helpful to different organizations and individuals. For the project implementor (PCA), in terms of programs to be implemented for the farmers. Policy inputs that will be formulated by the researcher can help in crafting appropriate programs for the benefit of the coconut farmers. For the other government agencies, in implementing their programs for farmer beneficiaries. The results of this research can also help in designing and redesigning future coconut programs. For future researchers, the results of this research can be used as secondary data by researchers in studying the overall impact assessment of the KAANIB Enterprise Development Project as implemented by the PCA. Also, the results of the study can be useful for future researchers if their area of interest is the effectiveness of government projects on the welfare of the farmer beneficiaries. For local government units, the results of this study

can be a basis for local government units in helping the coconut farmers solve the problems and challenges to be gathered, if there are any, being the closest support system in terms of government interventions. And for coconut farmers, the results of the study can help small-scale coconut farmers in solving the current problems and challenges they are facing in terms of government project interventions, if there are any.

The objective of the study was to assess the effectiveness of the KAANIB Enterprise Development Project (KEDP) – Community Household Level Coconut Processing Project (CHLCPP) component of the PCA in Kibawe, Bukidnon, 10 years after its implementation in the municipality. It seeks to identify the change brought about by the project to the farmer beneficiaries after its implementation.

2. MATERIALS AND METHODS

2.1 Study area

The study used the theory of effectiveness by Bullock (2006) to identify the change brought about by the project. The study covered Kibawe and Damulog, Bukidnon, in the Northern part of Mindanao, Philippines, since it is the second largest coconut area in terms of hectares according to the Philippine Statistics Authority in 2021, and the municipalities were the first beneficiaries of the KEDP–CHLCPP in the Philippines in general by the PCA. Figure 1 shows the Map of Bukidnon with emphasis on Kibawe and Damulog.

2.2 Procedures

A total of 140 respondents were identified using complete enumeration with the help of the Division Chief of the PCA in Bukidnon. These respondents were the farmer-beneficiaries of the project by the PCA.

A baseline survey was used as secondary data to identify the profitability of farmer beneficiaries before the project implementation, and primary data were gathered and calculated from it and were used to identify the profitability of the farmer-beneficiaries after project implementation.

A before-and-after approach is a method that identifies variables that indicate impact attainment. Indicators can be used both prospectively during planning as milestones and targets, and retrospectively to determine whether planned impacts were met. Categories or logical structures can be used to identify, organize, and evaluate indicators (Reed et al., 2021).

A similar study conducted by Daryanto et al. (2021) examined the difference in the financial performance of PT Japfa Comfeed Indonesia before and during the COVID-19 pandemic to determine the company's ability to generate profit before and during the pandemic, which provides insight into the company's future financial plan. Profitability parameters such as return on assets, return on invested capital, return on equity, gross margin percentage, and profit margin were assessed in terms of financial performance. In addition, the study of Golestani and Fallah (2019) was conducted using the Before and After method. The purpose of the study was to analyze the profitability proportions in companies before and after the implementation of corporate governance in companies listed on the Tehran Stock Exchange. The research was descriptive and causal-comparative in nature. Also, Putra et al. (2014) conducted a before-and-after research. The study's goal was to compare the financial performance of the oil and gas sector before and after the global financial crisis.

2.3 Research instrument

The research instrument that was used includes a cover letter and the main questionnaire. The cover letter explains the objectives and the overall concept of the study, asking for the commitment of the respondents to participate in the research. The researchers used the questionnaire adopted from the PCA with some degree of modification. It was not subjected to validation since it was the standard questionnaire used by the PCA. It was subject to proofreading, editing, and pilot testing with a Cronbach's alpha result of 0.867. It was a personal interview conducted by the researcher. It was more practical for the researchers to do a personal interview to gather all the data needed to satisfy the research objectives.

2.4 Data analysis and validation

Data were analyzed using a paired sample t-test to evaluate if there were any significant differences in the CBO's ability to generate income before and after the project implementation to determine the outcome brought about by the KEDP - Community Household Level Coconut Processing Project (CHLCPP). These data were validated by a focus group discussion with a total of 7 representatives. The researcher asked further questions about the results of the data gathered and analyzed.

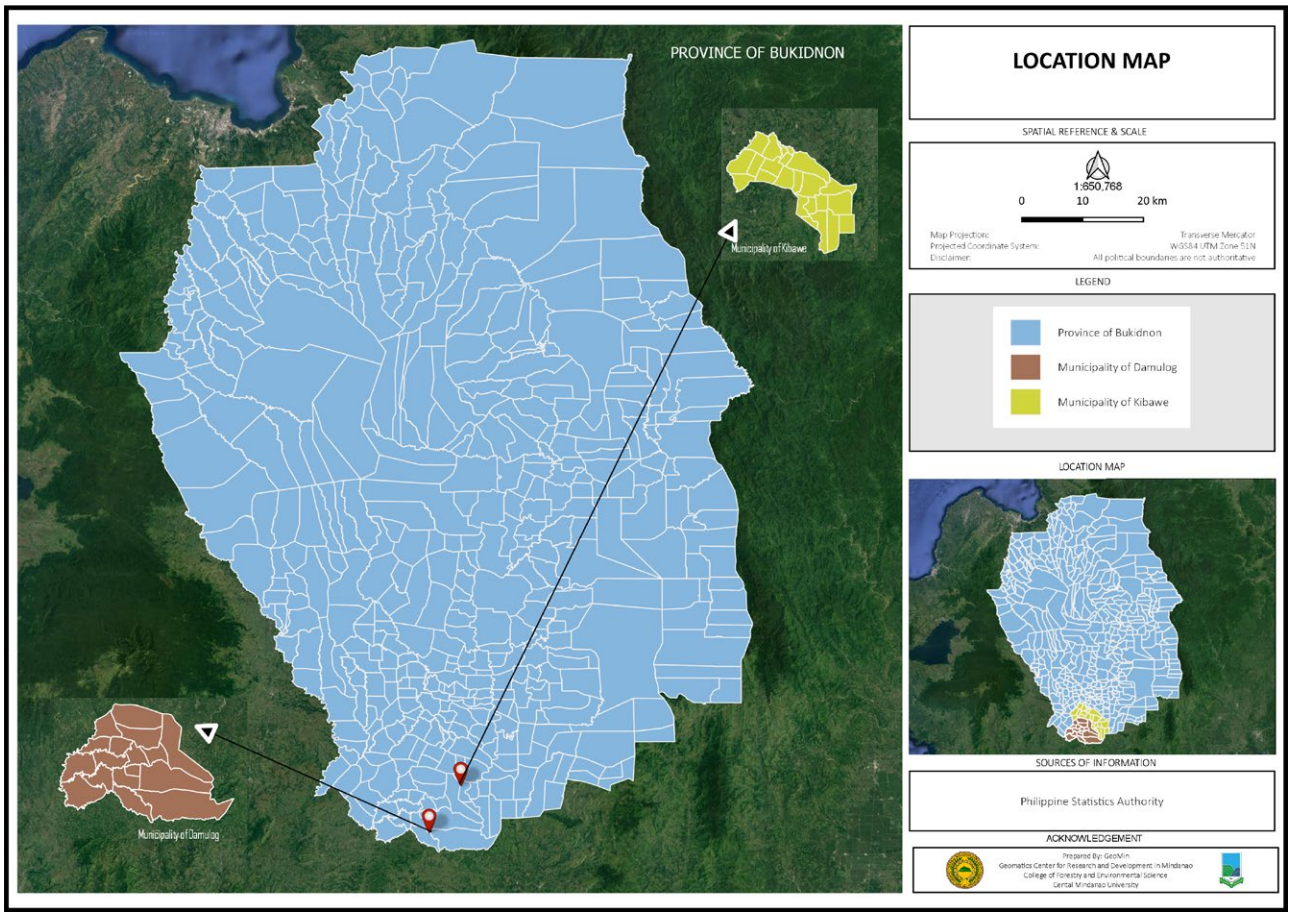

Figure 1. Map of Bukidnon highlighting the municipalities of Kibawe and Damulog. Source: Philippine Statistics Authority, 2022. Acknowledgement: GeoMin – Geomatics Center for Research and Development in Mindanao.

2.5 Ethical consideration

The research was conducted by observing research ethics. Permission to conduct the study was sought from the municipal Mayor of Kibawe, and an Institutional Ethics Review Committee (IERC) permit was secured from Central Mindanao University before the conduct of the study.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic profile of the beneficiaries of the project

This sector highlights the data gathered exclusively from the conduct of the research, stating the socio-demographic profile of the farm-beneficiaries of the project from the two municipalities in Bukidnon.

Table 1 shows the distribution of farmers according to gender. It was found out that sixty-seven per cent (67%) or about 94 beneficiaries were females. This result undermines the 2002 Census of Agriculture and Fisheries (CAF) conducted by the Philippine Statistics Authority (2009), that male operators dominated the agriculture sector. Of the 4.8 million farmers, 89% were male operators, while 11% comprised the female operators. The farmer beneficiaries mentioned during data validation that most of the males work in the farms, while most of the females work in the processing site. Moreover, a study conducted by Lu (2007) shows that male farmers outnumber female farmers. In addition, a study was also conducted by Ani and Casasola (2020) that shows that women do not have enough representation as well in key decision-making bodies such as local government units, rural organizations and farmers' cooperatives. The organizations also employed women, since it is one of the objectives of the KAANIB Enterprise Development Project. Nevertheless, it only shows that the agriculture sector is changing from a traditionally male-dominated sector to a female-dominated sector.

Table 1. Socio-demographic profile of farmer beneficiaries.

Item	Frequency	Percent
Gender		
Male	46	33
Female	94	67
Total	140	100
Address		
Kibawe, Bukidnon	70	50
Damulog, Bukidnon	70	50
Total	140	100
Age		
70 years old above	21	15
61 – 70 years old	29	21
51 – 60 years old	52	37
41 – 50 years old	22	16
40 years old below	16	11
Total	140	100
Religion		
Catholic	132	94
Others (Jehovah's Witness and Baptist)	8	6
Total	140	100
Ethnicity		
Cebuano	98	70
Boholano	38	27
Ilocano	2	1
Surigaonon	1	1
Camiguinon	1	1
Total	140	100
Highest Educational Attainment		
Elementary level	44	32
High School level	63	45
College level	20	13
College graduate	12	9
Post graduate level	0	0
Vocational Education	1	1
Total	140	100
Employment Status		
Employed	2	2
Unemployed	6	4
Farming	130	92
Others	2	2
Total	140	100
Number of years as Coconut Farmer		
20 years below	45	32
16 – 20 years	15	11
11 – 15 years	44	31
5 – 10 years	30	22
5 years below	6	4
Total	140	100
Ownership status of the farm		
Owned	115	82
Leased	3	2
Tenanted	20	15
Rented	2	1
Total	140	100
Housing ownership/ status		
Rented	7	5
Owned	133	95
Total	140	100

Shown also in Table 1 is the distribution of respondents according to their addresses. The respondents were situated in two different municipalities in Bukidnon, Kibawe and Damulog. These two municipalities were the first recipients of Coconut sugar technology and Virgin coconut oil technology in the region, respectively. Since the study used complete enumeration, the Division Chief, with the help of the Coconut Development Officer, identified 70 respondents at each site. These 70 respondents at each site were the original recipients way back in 2013. Thus, fifty per cent (50%) of the respondents were from Kibawe, and another fifty per cent (50%) were from Damulog, Bukidnon.

Table 1 also reveals the age distribution of the coconut farmers. The finding implies that thirty seven percent (37%) of the farmer beneficiaries belong to the 51-60 years old age group, twenty-one (21%) belong from the 61-70 years old age group, sixteen percent (16%) belong to the 41-50 years old group, fifteen percent (15%) of the farmers belong to the 70 years old above age group, and the remaining eleven percent (11%) were the youngest which belongs to the 40 years old and below group. The average age of farmers engaged in coconut farming is 60 years old, with 84 years old as the oldest and 36 years old as the youngest. This goes to show that farmers were already at retirement age. This corroborates with the Department of Agriculture (DA) survey in 2017 that the average age of farmers was 60 years old (Inso, 2018). According to Abbott (2019), in the year 2019, the average age of farmers was 59 years old, considered as "principal operator". Nonetheless, these farmers have a long range of experience in coconut farming and hope to teach the cultural management practice of coconut to their next generations.

The distribution of farmers according to religious affiliation is also shown in Table 1. The result indicates that ninety-four per cent (94%) or 132 of the farmers were Roman Catholics, and the remaining six per cent

(6%) or 8 farmers were divided among other religions like Jehovah's Witnesses and Baptists. Accordingly, there were fewer than non-Catholic members because most of the non-Catholic members of the community lived in the mountains, where communication is very difficult and roads are not very accessible. This indicates that among the farmers, Roman Catholicism is dominant in both Kibawe and Damulog, Bukidnon areas. This result conforms to the report of PSA (2010) that among the household population in Bukidnon, 76.5% were Roman Catholics, which comprised the largest among the population.

It can be gleamed from Table 1 that (70%) of the respondents were Cebuanos and twenty-seven per cent (27%) were Boholanos. As supported by the focus group discussion, most of the ancestors of the farmers were Cebuanos and Boholanos who were the first few people who inhabited the Municipalities of Kibawe and Damulog, Bukidnon. The remaining percentages were farmers who were Ilocano, Surigaonon and Camiguinon, respectively.

The distribution of farmers according to educational attainment is also revealed in Table 2. The finding of the study implies that forty-five per cent (45%) of the farmers were holders of high school level education, thirty-two per cent (32%) of the farmers have an elementary level degree, thirteen per cent (13%) were college level degree while one per cent (1%) were vocational education degree holders. This indicates that farmers attained basic education. Due to the lack of financial resources back then, the respondents were not able to go to higher education because they were forced to do farming for them to have food on their tables. Thus, this result supports the PSA (2013) survey, where they found that from the total household population, the largest portion of the population had finished at most high school.

As reflected in Table 1, employment status, ninety-two (92%) of the beneficiaries were full-time farmers, as their employment, unemployed respondents were also six per cent (6%), and the remaining percentages were distributed to public and private employees, which were two per cent each (2%). This is because most of the farmer beneficiaries were not able to finish higher education courses, and most of them only knew how to farm. Thus, farming plays an important role in the community. According to a study conducted by Jimenez et al. (2018), agriculture is the main economic driver in Bukidnon, with farming being the primary agricultural activity.

Data shows that in terms of number of years as coconut farmers, thirty-two per cent (32%) had been in the coconut farming for more than 20 years, thirty-one per cent (31%) were farming for 11-15 years, twenty-two per cent (22%) were farming for 5-10 years, eleven per cent (11%) were farmers for 16-20 years and the remaining four per cent (4%) were just new at farming and had been doing so for 5 years and below (Table 2). The farmer beneficiaries had been farming for more than 20 years due to familial ties and a lack of alternative livelihood options in the community, as supported by the focus group discussion. Moreover, farmers involved in farming for several years are expected to perform better than new ones. According to a study by Sivapragasam et al. (2019), coconut farming provides a stable source of income for many farmers in developing countries, where agriculture is the mainstay of the economy. As such, farmers who have invested significant time and resources in coconut farming may be reluctant to abandon their livelihoods. Also, farmers experience bridge theory and practice, which may affect farmers' openness in accepting and participating in agricultural programs (Francis et al., 2014).

Table 1 shows the distribution of farmers according to the ownership status of the farm. Eighty-two per cent (82%) of the farmers were land owners. This indicates that most farmers work on their own farm. This result corroborates the report of PSA (2009) that the majority (80%) of the agricultural operations were engaged in their own landholdings.

Household ownership or status of the farmer beneficiaries is also seen in Table 1. About ninety-five per cent (95%) of the farmer beneficiaries own their households, while the remaining five (5%) are renting their households. A study conducted by the International Labour Organization (2018) in the Philippines found that coconut farmers were among the poorest agricultural workers in the country, with high levels of debt and limited access to social services and financial resources. Though these beneficiaries were considered poor, these beneficiaries were able to build their own houses out of the small income they had from their farms.

3.2 Difference in the Profitability of the Beneficiaries before and after the implementation of the program

A paired sample t-test was used to identify the difference between the profitability of the farmers in terms of Return on Investment (ROI), Return on Asset (ROA), Return on Equity (ROE), Gross Profit Margin (GPM), and Net Profit Margin (NPM) before and after the KAANIB Enterprise Development Project. Similarly, Aisah et. al. (2023) used a paired sample t-test to determine the differences between two variables. According to the American Psychological Association (2020), a p-value of 0.05 or less is generally considered statistically significant.

Table 2 below shows the two-tailed paired sample t-test on the profitability of the farmer beneficiaries in

Table 2. Summary of the paired samples test among farmer beneficiaries before and after project implementation at Kibawe, Bukidnon, Philippines.

Indicators		Mean	Standard Deviation	t	p-value
Pair 1	Return on Investment	-26.12	101.47	-2.154	0.035**
Pair 2	Return on Asset	-44.49	126.61	-2.940	0.004**
Pair 3	Return on Equity	-18.26	81.64	-1.871	0.066
Pair 4	Gross Profit Margin	-16.72	57.89	-2.416	0.018**
Pair 5	Net Profit Margin	-15.44	38.39	-3.365	0.001**

Note: **significant at 0.05 p-value.

Kibawe, Bukidnon. A baseline survey was conducted by the PCA before the start of the KEDP in Kibawe, Bukidnon. It was used as the data before project implementation, and gathered the data after project implementation through personal interviews.

The standard deviation represents the average level of variation in a dataset. It tells how far each value deviates from the mean on average. A high standard deviation indicates that values are spread out from the mean, while a low standard deviation indicates that values are close to the mean (Bhandari, 2020).

In terms of Net Profit Margin, it is one indicator of the company's financial performance. In the cruise industry, for example, leading cruise operators exhibited consistently strong growth in net profit margins between 2016 and 2019. In contrast to most commercial shipping segments, which experienced sharp and prolonged revenue declines following the 2008 global financial crisis, cruise shipping demonstrated remarkable resilience and a relatively rapid recovery (Budiyanta, 2021).

The result shows a 101.47 standard deviation on the return on investment, 126.61 on the return on asset, 81.64 on the return on equity, 57.89 on the gross profit margin, and 38.39 on the net profit margin before and after project implementation. Thus, the profitability ratio values of the 70 respondents from Kibawe, Bukidnon, were far from the mean, indicating that each farmer's net income and net investment, total assets, total equity, net sales, gross profit, and net profit before and after project implementation has huge differentiation from each other. Some farmers have high profitability, and some farmers have low to negative profitability. Also, it goes to show that one farmer beneficiaries' profitability ratio has high variability in another's profitability ratio. Since the KEDP – CHLCPP was just an additional income to the farmer beneficiaries, some beneficiaries were earning long before the start of the project, while others just started earning because of the project.

The result shows a significant difference of 0.035 in the return on investment of the farmer beneficiaries before and after project implementation, which was considered statistically significant at a p-value of 0.05. Thus, the intervention of the government, specifically the PCA, was effective in changing the ROI of the farmer beneficiaries. Thus, it follows that return on investment (ROI) is a metric that may be used to assess a company's profitability as well as reveal the origins of its competitive advantages (Mauboussin and Callahan, 2014; Baldwin, 2016).

The result also shows a significant difference of 0.004 in the return on asset of the farmer beneficiaries before and after project implementation, and was also considered statistically significant at a p-value of 0.05. Thus, the intervention of the government, specifically the PCA, was effective in changing the ROA of the farmer beneficiaries. The farmer beneficiaries' net income and utilization of the total assets changed significantly over 10 years of project implementation.

A 0.066 significant difference was calculated on the return on equity before and after project implementation. This means that the p-value was not statistically significant. The value before project implementation lacks evidence that the project was effective in changing the return on equity of the farmer beneficiaries 10 years after project implementation. The beneficiaries were not able to significantly convert their available equity before and after project implementation. Because the given technology by the implementing agency was not according to the needs of the community.

A paired sample t-test yields a non-significant result for the return on equity variable, suggesting that there is no statistically significant difference between the paired ROEs being compared. This means that the ROE did not change significantly before and after project implementation.

The gross profit margin's significant difference shows a value of 0.018, which was considered statistically significant. The project was effective in changing the gross profit of the farmer beneficiaries 10 years after project implementation.

Lastly, a net profit margin of 0.001 significant difference before and after project implementation. The project was effective in changing the net profit against the total sales of the farmer beneficiaries. Results show a significant change in the net profit of farmer beneficiaries 10 years after the implementation of the project.

Also, the data below shows the significant difference in the ROI, ROA, ROE, GPM, and NPM of the farmer beneficiaries after the PCA gave them coconut sugar processing as part of their project. And the net margin is perhaps the most important measure of a company's overall profitability. It is the ratio of net profits to revenues for a company or business segment. Expressed as a percentage, the net profit margin shows how much profit is generated from every $1 in sales, after accounting for all business expenses involved in earning those revenues. Larger profit margins mean that more of every dollar in sales is kept as profit (Murphy, 2022).

According to Zamfir et al. (2016), the value of ROI can be either positive or negative. A positive ROI indicates a profitable project, while a negative ROI indicates otherwise. Therefore, the bigger the value of ROI, the better the investment would be.

Table 3 shows the two-tailed paired sample t-test on the profitability of the farmer beneficiaries in Damulog, Bukidnon. A baseline survey was conducted by the PCA before the start of the KEDP in Damulog, Bukidnon. It was used as the data before project implementation, and gathered the data after project implementation through personal interviews.

The result shows a 72.38 standard deviation on the return on investment, 56.28 on the return on asset, 61.2 on the return on equity, 146.43 on the gross profit margin, and 57.32 on the net profit margin before and after project implementation. Thus, the profitability ratio values of the 70 respondents from Damulog, Bukidnon were far from the mean, indicating that each farmer's net income and net investment, total assets, total equity, net sales, gross profit and net profit before and after project implementation has huge differentiation from each other. Just like the farmer beneficiaries from Kibawe, Bukidnon, there are also farmers who have high profitability, and there are also farmers who have low to negative profitability. Also, it goes to show that one farmer beneficiaries' profitability ratio has high variability in another one's profitability ratio. Because the KEDP – CHLCPP was just an additional income to the farmer beneficiaries, some beneficiaries were earning long before the start of the project, while others just started earning because of the project, the same with the farmer beneficiaries in Kibawe, Bukidnon.

The result shows a significant difference of 0.006 in the return on investment of the farmer beneficiaries before and after project implementation, which was considered statistically significant at a p-value of 0.05. Thus, the intervention of the government, specifically the PCA, was effective in changing the ROI of the farmer beneficiaries. The farmer beneficiaries' net income and total investment changed significantly over 10 years of project implementation. Thus, the null hypothesis, which states that the Return on Investment of farmer beneficiaries has no significant difference before and after the implementation of the KAANIB Enterprise Development Project, is to be rejected.

The result also shows a significant difference of 0.167 in the return on asset of the farmer beneficiaries before and after project implementation, and was not considered statistically significant at a p-value of 0.05. Thus, the intervention of the government, specifically the PCA, was not effective in changing the ROA of the farmer beneficiaries. The farmer beneficiaries' net income and utilization of the total assets has no significant change over 10 years of project implementation. The equipment given was not totally used due to the absence of a market, and the equipment given does not match the needs of the organization. Thus, the null hypothesis, which states that the Return on Asset of farmer beneficiaries has no significant difference before and after the implementation of the KAANIB Enterprise Development Project, is to be accepted.

A paired sample t-test yields a non-significant result for the return on asset variable, suggesting that there is no statistically significant difference between the paired ROA's being compared. It means that the ROA did not change significantly before and after project implementation. According to a study by Atidhira and Yustina (2017) it shows that a good profitability performance by an enterprise can be really seen by considering other profitability ratios, and when the customers are able to use the technology given, thus the community benefits from it.

A 0.004 significant difference was calculated on the return on equity before and after project implementation. This means that the p-value was statistically significant. The value before project implementation has sufficient evidence showing a significant difference that the project was effective in changing the return on equity of the farmer beneficiaries 10 years after project implementation. Thus, the null hypothesis, which states that the Return on Equity of farmer beneficiaries has no significant difference before and after the implementation of the KAANIB Enterprise Development Project, is to be rejected.

Table 3. Summary of the paired samples test among farmer beneficiaries before and after project implementation at Damulog, Bukidnon, Philippines.

	Indicators	Mean	Standard Deviation	t	p-value
Pair 1	Return on Investment	-24.71	72.38	-2.85	0.006**
Pair 2	Return on Asset	-9.39	56.28	-1.40	0.167
Pair 3	Return on Equity	-21.6	61.2	-2.95	0.004**
Pair 4	Gross Profit Margin	-60.28	146.43	-3.44	0.001**
Pair 5	Net Profit Margin	-16.10	57.32	-2.50	0.022**

Note: **significant at 0.05 p-value.

3.3 Thematic analysis in identifying the problems before, during and after project implementation

There were several problems that the farmer beneficiaries encountered before, during and after the implementation of the KAANIB Enterprise Development Program (KEDP), specifically the Community Household Level Coconut Processing Project (CHLCPP) component. These problems were identified by the farmers during data collection and focus group discussion.

Farmers' involvement in government programs has been found to have a positive impact on farmer morale. According to a study conducted by Johnson et al. (2018), active participation of farmers in government initiatives and decision-making processes increases their sense of ownership and engagement, leading to improved morale within the farming community.

According to a study by Rambaldi et al. (2018), the cost of support systems can be a barrier for farmers, particularly small-scale farmers who do not have the financial capacity to access these services.

Kibawe, Bukidnon, identified a problem with the lack of labor, especially coconut toddy collector, because their trained collector died. With the absence of the collector, raw material such as toddy or vernacularly known as "tuba" was not available. And accordingly, the "tuba" collection is very crucial because it needs to be collected at a specified time, failure to collect on the said time may lead to spoilage of the "tuba".

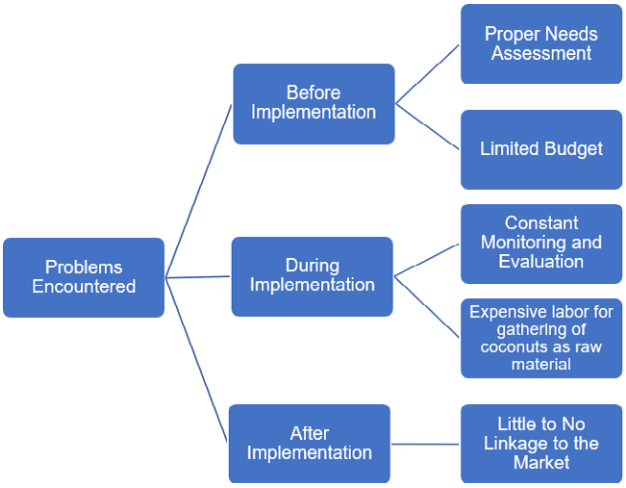

Figure 2. Thematic diagram of the problems encountered.

Damulog, Bukidnon, identified a problem with the shift of officers. The old officers were replaced by new ones who have little knowledge about virgin coconut oil processing. Nonetheless, the old officers were still part of the organization and helped in maintaining the production of virgin coconut oil and other products from coconut by products.

According to Yusuf and Surjaatatmadja (2018), profitability is also significant in terms of a firm's long-term survival because it signals whether the company has high future possibilities. Profitability ratios are classified into two types: margin ratios and return ratios.

The summary of the problems encountered before, during and after the implementation of KAANIB Enterprise Development Project (KEDP) – Community Household – Level Coconut Procession Project (CHLCPP) component of the PCA is shown in Figure 2.

4. CONCLUSION

Results of the paired t-test showed that the Return on Investment, Return on Asset, Net Profit Margin, and Gross Profit Margin were statistically significant before and after the program was implemented. However, the Return on Equity was considered not statistically significant in terms of profitability before and after the program was implemented in the case of Kibawe, Bukidnon. On the other hand, in the case of Damulog, Bukidnon, Return on Investment, Return on Equity, Gross Profit Margin, and Net Profit Margin were statistically significant, while the Return on Asset was not statistically significant.

There were problems encountered before project implementation, which were the conduct of proper needs

assessment, limited budget of the implementing agency, during project implementation, which were constant monitoring and evaluation and expensive labor for gathering of coconuts as raw materials, and after the project implementation, which was the absence of market and little to no linkage.

5. RECOMMENDATION

A properly conducted needs analysis would be recommended to the implementing agency. A needs analysis identifies causes and solutions to challenges or problems. It can be thought of as the process of identifying and accounting for the gaps between what should and should not be happening. Additionally, the implementing agency should conduct monitoring and evaluation of the technologies given at least once or twice a month in order for the government agency to have information on what happened with the technology they gave. To further know the status of the technology, whether it is still functional or not, constant monitoring must be done. If it is not functional, identify other organizations that need the technology in order for the investment of the government not to go to waste.

To maintain and enhance these technologies, continuous training should be offered to farmers to guarantee effective adoption of technology and adjustment to local circumstances. Furthermore, encouraging collaboration between farmers, local government, research organizations, and private sector stakeholders will promote knowledge sharing and the spread of innovation, allowing for the creation of customized circular economy models suited to local needs.

ACKNOWLEDGEMENT

The PCA Region X, considered as the implementor of the project, Municipal Mayor of Kibawe and Damulog, considered as the farmer beneficiaries of the project, the author is beyond blessed to have worked with them in finishing this research and hopes to have more research collaborations in the future.

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AESTIMUM
CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.

Firenze University Press
www.fupress.com/ceset

Citation: Lucifero, N. (2026). Rassegna giurisprudenziale I semestre 2026. *Aestimum* 88: 123-138. doi: 10.36253/aestim-20894

Published: September 11, 2026

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Rassegna giurisprudenziale I semestre 2026

A CURA DI NICOLA LUCIFERO

AGRICOLTURA E PESCA

Corte giustizia Unione Europea, Sez. VI, Sentenza, 21/05/2026, C-52/25
Rinvio pregiudiziale – Aiuti di Stato – Esenzione per categoria di alcuni aiuti ai settori agricolo e forestale – Regolamento (UE) n. 702/2014 – Aiuti destinati a indennizzare i danni causati da avversità atmosferiche assimilabili a calamità naturali – Riduzione dell'importo dell'aiuto in caso di mancata stipula di una polizza assicurativa che copra almeno il 50% della produzione media annua o del reddito ricavato dalla produzione nonché i rischi climatici più frequenti nello Stato membro o nella regione di cui trattasi – Articolo 25, paragrafo 9 – Impossibilità per il beneficiario dell'aiuto di stipulare la polizza assicurativa richiesta
1) L'articolo 25, paragrafo 9, del regolamento (UE) n. 702/2014 della Commissione, del 25 giugno 2014, che dichiara compatibili con il mercato interno, in applicazione degli articoli 107 e 108 [TFUE], alcune categorie di aiuti nei settori agricolo e forestale e nelle zone rurali, deve essere interpretato nel senso che un aiuto destinato a indennizzare una piccola o media impresa (PMI) attiva nella produzione agricola primaria per un danno causato da avversità atmosferiche assimilabili a calamità naturali deve essere ridotto della metà qualora tale PMI non sia assicurata contro i rischi climatici statisticamente più frequenti nello Stato membro o nella regione di cui trattasi, in una situazione in cui l'aiuto in questione mira a indennizzare un danno causato da simili avversità atmosferiche che, da un lato, non rientrano in tali rischi e, dall'altro, non costituiscono un rischio che è possibile assicurare in tale Stato membro o nella regione di cui trattasi.
2) L'articolo 25, paragrafo 9, del regolamento n. 702/2014 deve essere interpretato nel senso che un aiuto destinato a indennizzare una piccola o media impresa (PMI) attiva nella produzione agricola primaria per un danno causato da avversità atmosferiche assimilabili a calamità naturali non deve essere ridotto della metà qualora tale PMI non sia stata in grado di stipulare una polizza assicurativa che soddisfi le condizioni di detta disposizione per il tipo di produzione della sua azienda, tenuto conto dell'offerta disponibile sul mercato assicurativo pertinente.

Corte giustizia Unione Europea, Sez. I, Sentenza, 26/03/2026, C-434/24
Rinvio pregiudiziale – Agricoltura – Politica agricola comune – Fondo europeo agricolo di garanzia (FEAGA) – Regime di pagamento unico per

superficie – Regolamento (UE) n. 1307/2013 – Articolo 32, paragrafi 2 e 4 – Ettaro ammissibile – Articolo 36, paragrafo 5 – Ettari a disposizione dell'agricoltore – Normativa nazionale che richiede la produzione del contratto di affitto della superficie agricola – Annullamento con effetto retroattivo di tale contratto a causa di un'irregolarità della procedura di assegnazione non imputabile a tale agricoltore – Regolamento (UE) n. 1306/2013 – Articolo 63, paragrafo 1 – Ammissibilità della domanda

Il regolamento (UE) n. 1306/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, sul finanziamento, sulla gestione e sul monitoraggio della politica agricola comune e che abroga i regolamenti del Consiglio (CEE) n. 352/78, (CE) n. 165/94, (CE) n. 2799/98, (CE) n. 814/2000, (CE) n. 1290/2005 e (CE) n. 485/2008, come modificato dal regolamento (UE) 2017/2393 del Parlamento europeo e del Consiglio, del 13 dicembre 2017, nonché il regolamento (UE) n. 1307/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, recante norme sui pagamenti diretti agli agricoltori nell'ambito dei regimi di sostegno previsti dalla politica agricola comune e che abroga il regolamento (CE) n. 637/2008 del Consiglio e il regolamento (CE) n. 73/2009 del Consiglio, devono essere interpretati nel senso che essi ostano a che l'amministrazione nazionale competente consideri che una domanda di pagamento unico per superficie sia divenuta inammissibile, per il solo motivo che il contratto di affitto avente ad oggetto la superficie agricola cui si riferisce tale domanda, prodotto a sostegno di quest'ultima al fine di dimostrare, conformemente alla normativa nazionale, che la superficie agricola è a disposizione dell'agricoltore, e che era valido al momento dell'esame di detta domanda, è stato successivamente annullato, con effetto retroattivo, a causa di un'irregolarità della procedura di assegnazione di tale contratto, irregolarità non imputabile all'agricoltore, indipendentemente dalla data di annullamento di detto contratto.

Corte giustizia Unione Europea, Sez. I, Sentenza, 05/02/2026, C-364/24

Rinvio pregiudiziale – Ambiente – Emissione deliberata nell'ambiente di organismi geneticamente modificati (OGM) – Misure volte ad evitare la presenza involontaria di OGM nell'ambiente – Direttiva 2001/18/CE – Articolo 26 quater, paragrafi 1 e 3 – Regolamento (CE) n. 1829/2003 – Decisione di esecuzione (UE) 2016/321 – Divieto di coltivazione del mais OGM MON 810 in Italia – Validità – Libera circolazione delle merci – Articoli 34 TFUE e 114 TFUE – Principi di proporzionalità e di non discriminazione – Libertà d'impresa – Articoli 16 e 21 della Carta dei diritti fondamentali dell'Unione europea

L'articolo 26 quater, paragrafi 1 e 3, della direttiva 2001/18/CE, come modificata dalla direttiva (UE) 2015/412, che permette agli Stati membri di vietare in tutto o in parte del loro territorio la coltivazione di OGM senza obbligo di motivazione specifica e con il consenso tacito del titolare dell'autorizzazione, è valido alla luce dell'articolo 3 TUE, degli articoli 18, 26, 34-36, 114, 216 TFUE, nonché degli articoli 16 e 21 della Carta dei diritti fondamentali dell'Unione Europea e dei principi di non discriminazione e proporzionalità.

Cass. civ., Sez. III, Ordinanza, 14/05/2026, n. 14200

Titoli PAC-diritti agli aiuti comunitari-contratto di cessione-natura consensuale-effetti reali-art. 1376 c.c.-trasferimento della proprietà-AGEA-adempimenti amministrativi-funzione dichiarativa-opponibilità-Pubblica Amministrazione-erogazione degli aiuti-elementi costitutivi-pignoramento-patrimonio del debitore-iter amministrativo

In tema di titoli PAC (diritti agli aiuti comunitari in agricoltura), il contratto di cessione stipulato tra privati ha natura consensuale e, ai sensi dell'art. 1376 c.c., produce effetti reali immediati tra le parti al momento della conclusione, con conseguente uscita dei titoli dal patrimonio del cedente; gli adempimenti presso AGEA (comunicazione, registrazione, istanza telematica) hanno funzione meramente dichiarativa ed incidono solo sull'opponibilità alla Pubblica Amministrazione ai fini dell'erogazione degli aiuti, senza integrare elementi costitutivi del trasferimento sul piano civilistico. Ne consegue che il pignoramento successivo alla cessione non può aggredire tali diritti, ormai estranei al patrimonio del debitore, a nulla rilevando che l'iter amministrativo presso AGEA sia stato completato in data posteriore.

Cons. Stato, Sez. VI, Sentenza, 10/06/2026, n. 4662

Regime di pagamento unico-Reg. CE n. 1782/2003-recupero degli aiuti-titolo di conduzione-contratto verbale di affitto-morte del proprietario-onere della prova-fatto impeditivo-Amministrazione-illegittimità del provvedimento-conduzione dei terreni-data di stipula-invalidità del titolo-agricoltore-aiuti comunitari

In tema di regime di pagamento unico (Reg. CE n. 1782/2003), è illegittimo il provvedimento di recupero degli aiuti fondato sulla mera affermazione, non dimostrata, dell'assenza di un valido titolo di conduzione dei terreni (nella specie, per asserita stipula del contratto verbale di affitto in data successiva alla morte della proprietaria). L'Amministrazione, che contesti la legittimità

della conduzione dichiarata, ha l'onere di provare il fatto impeditivo (inesistenza o invalidità del titolo), non potendo pretendere che l'agricoltore dimostri l'effettiva data di stipula del contratto verbale in assenza di elementi certi in senso contrario.

Cons. Stato, Sez. VI, Sentenza, 09/06/2026, n. 4634
Prelievo supplementare-quote latte-prescrizione-onere della prova-atti interruttivi-Amministrazione creditrice-eccezione di prescrizione-estinzione del credito-cartella esattoriale-annullamento-art. 64 comma 2 c.p.a.-giudizio-debitore
In materia di prelievo supplementare "quote latte", l'onere di provare l'esistenza di atti interruttivi della prescrizione grava integralmente sull'Amministrazione creditrice: ove il debitore eccepisca la prescrizione in modo specifico e l'Amministrazione non alleghi e non dimostri in giudizio alcun atto interruttivo, il giudice deve dichiarare estinto per prescrizione il credito e annullare la cartella, ai sensi dell'art. 64, comma 2, c.p.a.

Cons. Stato, Sez. VI, Sentenza, 20/04/2026, n. 3070
PAC-AGEA-organismo pagatore-Reg. UE n. 1306/2013-Reg. UE n. 907/2014-legittimità della spesa-interessi finanziari dell'Unione-potere di disapplicazione-atti amministrativi-determina comunale-revoca-concessioni pascolive-interdittiva antimafia-autotutela-ricorso giurisdizionale-organi di controllo-erogazione dei contributi-recupero dei contributi-tamquam non essent
In tema di gestione degli aiuti della PAC, l'AGEA - pur essendo organismo pagatore responsabile, ai sensi del Reg. (UE) n. 1306/2013 e del Reg. (UE) n. 907/2014, della legittimità e regolarità della spesa e della tutela degli interessi finanziari dell'Unione - non è titolare di alcun potere di disapplicazione dei provvedimenti adottati da altre amministrazioni nazionali. In presenza di atti ritenuti illegittimi (nella specie, una determina comunale di revoca di precedente risoluzione anticipata di concessioni pascolive a seguito di interdittiva antimafia), l'AGEA può e deve attivare gli ordinari rimedi previsti dall'ordinamento (sollecitare l'autotutela dell'amministrazione emanante, proporre ricorso giurisdizionale se legittimata, segnalare agli organi di controllo), ma non può considerarli tamquam non essent ai fini dell'erogazione o del recupero dei contributi.

Cons. Stato, Sez. VI, Sentenza, 27/03/2026, n. 2574
Aiuti PAC-affidamento del beneficiario-organismo pagatore-superfici dichiarate-controlli amministrativi-controlli in loco-principio di buona fede-art. 1 comma 2-bis L. n. 241/1990-carattere bilaterale-dichiarazioni del produttore-veridicità delle dichiarazioni-onere di aggiornamento-superfici a premio-erogazione dei contributi
In materia di aiuti PAC, l'affidamento del beneficiario non può dirsi leso dalla successiva attività di controllo dell'Organismo pagatore sulle superfici dichiarate, allorché il sistema di erogazione dei contributi sia normativamente strutturato su dati dichiarati dal privato e su controlli amministrativi e in loco ex post: il principio di buona fede ex art. 1, comma 2-bis, L. n. 241/1990 ha carattere bilaterale e tutela anche l'affidamento dell'Amministrazione sulla veridicità e completezza delle dichiarazioni del produttore, cui incombe l'onere di aggiornare i dati e di indicare correttamente le superfici a premio.

Cons. giust. amm. Sicilia, Sentenza, 01/06/2026, n. 325
Aiuti comunitari in agricoltura-superficie ammissibile-particelle fondiarie-titoli PAC-diritto ai contributi-amministrazione erogatrice-ordine istruttorio-criterio di calcolo-superfici dichiarate-superfici determinate-percentuali di scostamento-sanzioni-inadempimento istruttorio-art. 64 comma 4 c.p.a.-annullamento-atti di recupero-supporto probatorio-motivazione
In tema di aiuti comunitari in agricoltura, qualora il beneficiario deduca - con puntuali allegazioni - che, anche detraendo le particelle fondiarie oggetto di contestazione, egli conservi comunque una superficie ammissibile (o un numero di titoli) sufficiente al mantenimento del diritto ai contributi, l'amministrazione erogatrice è tenuta a fornire, su ordine istruttorio del giudice, chiara dimostrazione del criterio di calcolo delle superfici dichiarate e di quelle determinate, nonché delle percentuali di scostamento rilevanti ai fini sanzionatori; il perdurante inadempimento agli incombenti istruttori, valutato ai sensi dell'art. 64, comma 4, c.p.a., può condurre all'annullamento degli atti di recupero, risultando l'azione amministrativa priva di adeguato supporto probatorio e motivazionale.

T.A.R. Toscana Firenze, Sez. II, Sentenza, 28/05/2026, n. 1027
Aiuto all'avviamento di imprese-giovani agricoltori-insediamento-azienda agricola-24 mesi-domanda di sostegno-interpretazione del contratto-artt. 1362 e 1363 c.c.-impresa individuale-impresa societaria-attività di impresa agricola-titolare-socio-esclusione dal contributo-ditta individuale-biennio-legittimità dell'esclusione
In tema di bandi per l'"aiuto all'avviamento di imprese per giovani agricoltori", la clausola che richiede che il beneficiario "si insedi per la prima volta in un'azienda

agricola, nei 24 mesi precedenti la domanda di sostegno", va interpretata – secondo i canoni degli artt. 1362 e 1363 c.c. – nel senso che l'"insediamento" rilevante è quello dell'impresa (individuale o societaria) per la quale è chiesto il contributo e che deve essere attiva al momento della domanda; rispetto a tale insediamento, il giovane non deve aver svolto, in precedenza, attività di impresa agricola come titolare o socio di impresa agricola. Ne consegue la legittimità dell'esclusione dal contributo del richiedente che, prima della costituzione della società per cui chiede l'aiuto, abbia già esercitato un'attività agricola come ditta individuale, ancorché questa ricada nel medesimo biennio.

T.A.R. Campania Napoli, Sez. III, Sentenza, 03/04/2026, n. 2226

Procedimento telematico-pagamenti diretti-PAC-L. n. 241/1990-principi generali-obbligo di provvedere-provvedimento espresso-art. 2 L. n. 241/1990-conclusione del procedimento-finanziamenti vincolati-attività vincolata-discrezionalità amministrativa-regolamenti attuativi

La natura interamente telematica del procedimento di erogazione dei pagamenti diretti, disciplinato dai regolamenti e decreti nazionali attuativi della PAC, non esclude né attenua l'applicazione dei principi generali di cui alla L. n. 241/1990, ed in particolare l'obbligo di concludere il procedimento con un provvedimento espresso (art. 2), anche quando si tratti di finanziamenti vincolati e di attività priva di margini di discrezionalità.

T.A.R. Lombardia Milano, Sez. II, Sentenza, 06/03/2026, n. 1133

Contributi regionali-investimenti agricoli-impianto antigrandine-reimpianto-colture arboree specializzate-ammissibilità del contributo-contestualità-messa a dimora-bando-criteri predeterminati-art. 12 L. n. 241/1990-divieto di deroga-Amministrazione-finanziabilità

In tema di contributi regionali per investimenti nel settore agricolo, ove il bando, nel disciplinare il finanziamento degli interventi di impianto o reimpianto di colture arboree specializzate, preveda espressamente l'ammissibilità del contributo per l'impianto antigrandine "soltanto con contestuale realizzazione del relativo impianto" colturale, deve escludersi la finanziabilità dell'impianto antigrandine in assenza della contestuale messa a dimora di nuove piante, non potendo l'Amministrazione disapplicare o derogare ai criteri e alle condizioni da essa stessa predeterminati ai sensi dell'art. 12 della L. 7 agosto 1990, n. 241.

T.A.R. Emilia-Romagna Bologna, Sez. II, Sentenza, 25/02/2026, n. 332

Recupero degli aiuti-AGREA-legittimo affidamento-buona fede-termine di prescrizione-10 anni-4 anni-Reg. CE n. 796/2004-provvedimento di recupero-contributi agricoli-PAC-illegittimità-ricorso fondato

La richiesta di recupero degli aiuti in agricoltura da parte di Agrea non può ignorare il principio del legittimo affidamento del ricorrente alla percezione dell'aiuto, né trascurare i termini di perentorietà di 10 anni (ridotti a 4 anni in caso di buona fede) per il recupero del contributo fissati dal Regolamento CE n. 796/2004. Il ricorso contro tale provvedimento è fondato.

ALIMENTI E BEVANDE

Corte giustizia Unione Europea, Sez. III, Sentenza, 18/06/2026, C-658/24

Rinvio pregiudiziale – Libertà di stabilimento – Libera prestazione dei servizi – Organizzazione comune dei mercati dei prodotti agricoli – Servizi nel mercato interno – Normativa nazionale che prevede un obbligo, durante un periodo determinato, per i distributori di prodotti alimentari con un fatturato superiore a un determinato importo, di ridurre i prezzi di taluni prodotti alimentari e di disporre di quantitativi minimi di questi ultimi – Misure adottate in ragione di una situazione di pericolo – Ammende

1) Il regolamento (UE) n. 1308/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, recante organizzazione comune dei mercati dei prodotti agricoli e che abroga i regolamenti (CEE) n. 922/72, (CEE) n. 234/79, (CE) n. 1037/2001 e (CE) n. 1234/2007 del Consiglio, come modificato dal regolamento (UE) 2021/2117 del Parlamento europeo e del Consiglio, del 2 dicembre 2021, deve essere interpretato nel senso che esso osta alla normativa di uno Stato membro che, in considerazione di una situazione di pericolo, impone ai commercianti esercenti l'attività di vendita al dettaglio di prodotti alimentari con un fatturato annuo superiore a EUR 2 500 000, a pena di un'ammenda, da un lato, di applicare per talune categorie di prodotti rientranti nell'ambito di applicazione di tale regolamento, durante un periodo determinato, un prezzo lordo di vendita al dettaglio che sia inferiore di almeno il 15% al prezzo lordo di vendita al dettaglio più basso da essi applicato nei 30 giorni precedenti e, dall'altro, di disporre sempre, durante tale periodo, di quantitativi minimi di determinati prodotti.

2) L'articolo 14, paragrafo 1, e l'articolo 15 della direttiva 2006/123/CE del Parlamento europeo e del Consiglio, del

12 dicembre 2006, relativa ai servizi nel mercato interno devono essere interpretati nel senso che essi ostano alla normativa di uno Stato membro che, in considerazione di una situazione di pericolo, impone ai commercianti esercenti l'attività di vendita al dettaglio di prodotti alimentari con un fatturato annuo superiore a EUR 2 500 000, a pena di un'ammenda, da un lato, di applicare per talune categorie di prodotti, durante un periodo determinato, un prezzo lordo di vendita al dettaglio che sia inferiore di almeno il 15% al prezzo lordo di vendita al dettaglio più basso da essi applicato nei 30 giorni precedenti e, dall'altro, di disporre sempre, durante tale periodo, di quantitativi minimi di determinati prodotti.

Corte giustizia Unione Europea, Sez. III, Sentenza, 21/05/2026, C-626/24

Rinvio pregiudiziale – Libera circolazione delle merci – Controlli ufficiali dei prodotti alimentari – Regolamento (UE) 2017/625 – Articolo 9, paragrafo 7 – Armonizzazione esauriente – Normativa nazionale che prevede un obbligo di segnalazione all'arrivo di integratori alimentari provenienti da altri Stati membri – Requisito di stretta necessità per l'efficace organizzazione di controlli ufficiali per motivi imperativi di tutela della salute umana e dei consumatori

L'articolo 9, paragrafo 7, del regolamento (UE) 2017/625 del Parlamento europeo e del Consiglio, del 15 marzo 2017, relativo ai controlli ufficiali e alle altre attività ufficiali effettuati per garantire l'applicazione della legislazione sugli alimenti e sui mangimi, delle norme sulla salute e sul benessere degli animali, sulla sanità delle piante nonché sui prodotti fitosanitari, recante modifica dei regolamenti (CE) n. 999/2001, (CE) n. 396/2005, (CE) n. 1069/2009, (CE) n. 1107/2009, (UE) n. 1151/2012, (UE) n. 652/2014, (UE) 2016/429 e (UE) 2016/2031 del Parlamento europeo e del Consiglio, dei regolamenti (CE) n. 1/2005 e (CE) n. 1099/2009 del Consiglio e delle direttive 98/58/CE, 1999/74/CE, 2007/43/CE, 2008/119/CE e 2008/120/CE del Consiglio, e che abroga i regolamenti (CE) n. 854/2004 e (CE) n. 882/2004 del Parlamento europeo e del Consiglio, le direttive 89/608/CEE, 89/662/CEE, 90/425/CEE, 91/496/CEE, 96/23/CE, 96/93/CE e 97/78/CE del Consiglio e la decisione 92/438/CEE del Consiglio (regolamento sui controlli ufficiali), deve essere interpretato nel senso che osta a una normativa nazionale che impone a qualsiasi operatore destinatario di integratori alimentari provenienti da un altro Stato membro l'obbligo di segnalare in anticipo l'arrivo di tali integratori nel luogo di destinazione e di fornire i dati necessari all'analisi dei rischi che essi possono presentare e alla pianificazione dei controlli ufficiali.

Corte giustizia Unione Europea, Sez. III, Sentenza, 13/05/2026, C-483/24

Rinvio pregiudiziale – Salute – Legislazione alimentare – Regolamento (CE) n. 178/2002 – Principi e requisiti generali – Regolamento (CE) n. 852/2004 – Igiene dei prodotti alimentari – Articolo 4, paragrafo 2 – Obblighi generali e specifici incombenti a tutti gli operatori del settore alimentare – Portata – Allegato II – Requisiti generali in materia di igiene applicabili a tali operatori – Articolo 5 – Principi del sistema dell'analisi dei pericoli e dei punti critici di controllo (principi del sistema HACCP) – Portata – Ripetuta constatazione, da parte dell'autorità competente, di tracce e di deiezioni di animali infestanti in negozi e depositi di un'impresa alimentare – Reato previsto dal diritto nazionale in esecuzione dell'articolo 17, paragrafo 2, terzo comma, del regolamento n. 178/2002

Le disposizioni dell'allegato II, capitolo V, punto 1, lettera a), e capitolo IX, punti 2 e 3, del regolamento (CE) n. 852/2004 del Parlamento europeo e del Consiglio, del 29 aprile 2004, sull'igiene dei prodotti alimentari, lette in combinato disposto con l'articolo 4, paragrafo 2, e l'articolo 5, paragrafi 1 e 2, di tale regolamento, devono essere interpretate nel senso che la constatazione, da parte dell'autorità competente, di tracce e di deiezioni di animali infestanti in negozi e magazzini di un'impresa alimentare è sufficiente a dimostrare l'esistenza di una violazione degli obblighi incombenti all'operatore del settore alimentare che controlla tale impresa, in forza di dette disposizioni, senza che sia necessario provare inoltre che tale operatore non abbia attuato tutti i mezzi possibili per prevenire la presenza di tali animali.

Le disposizioni dell'allegato II, capitolo IX, punto 4, del regolamento n. 852/2004, lette in combinato disposto con l'articolo 4, paragrafo 2, e l'articolo 5, paragrafi 1 e 2, di quest'ultimo, devono essere interpretate nel senso checla constatazione ripetuta, da parte dell'autorità competente, della presenza di siffatte tracce e deiezioni di animali infestanti è sufficiente per constatare che detto operatore non ha adottato procedure adeguate per controllare tali animali.

Le disposizioni dell'allegato II, capitolo I, punto 2, lettera c), del regolamento n. 852/2004, lette in combinato disposto con l'articolo 4, paragrafo 2, e l'articolo 5, paragrafi 1 e 2, di tale regolamento, devono essere interpretate nel senso che la constatazione dell'esistenza di una violazione di tali disposizioni esige che sia dimostrato che le caratteristiche delle strutture di un'impresa destinate agli alimenti non consentano una corretta prassi di igiene alimentare.

Corte giustizia Unione Europea, Sez. I, Sentenza, 30/04/2026, C-301/25

Rinvio pregiudiziale – Tutela dei consumatori – Pratiche commerciali sleali delle imprese nei confronti dei consumatori – Direttiva 2005/29/CE – Ambito di applicazione – Relazione tra le disposizioni di tale direttiva e altre norme dell'Unione che disciplinano aspetti specifici delle pratiche commerciali sleali – Articolo 3, paragrafo 4 – Pratiche sleali in materia di informazioni sugli alimenti – Regolamento (UE) n. 1169/2011 – Esistenza di un contrasto – Complementarità dei regimi di tutela

L'articolo 3, paragrafo 4, della direttiva 2005/29/CE del Parlamento europeo e del Consiglio, dell'11 maggio 2005, relativa alle pratiche commerciali sleali delle imprese nei confronti dei consumatori nel mercato interno e che modifica la direttiva 84/450/CEE del Consiglio e le direttive 97/7/CE, 98/27/CE e 2002/65/CE del Parlamento europeo e del Consiglio e il regolamento (CE) n. 2006/2004 del Parlamento europeo e del Consiglio («direttiva sulle pratiche commerciali sleali»), deve essere interpretato nel senso che esso non osta a che, nel settore degli alimenti, il comportamento di un professionista che costituisca una pratica commerciale ingannevole, ai sensi dell'articolo 6, paragrafo 1, della direttiva 2005/29, possa essere sanzionato in applicazione della normativa nazionale di recepimento di detta direttiva, nel caso in cui tale comportamento rientri anche nel divieto previsto dall'articolo 7 del regolamento (UE) n. 1169/2011 del Parlamento europeo e del Consiglio, del 25 ottobre 2011, relativo alla fornitura di informazioni sugli alimenti ai consumatori, che modifica i regolamenti (CE) n. 1924/2006 e (CE) n. 1925/2006 del Parlamento europeo e del Consiglio e abroga la direttiva 87/250/CEE della Commissione, la direttiva 90/496/CEE del Consiglio, la direttiva 1999/10/CE della Commissione, la direttiva 2000/13/CE del Parlamento europeo e del Consiglio, le direttive 2002/67/CE e 2008/5/CE della Commissione e il regolamento (CE) n. 608/2004 della Commissione, e nella normativa nazionale di attuazione del regolamento n. 1169/2011.

Cass. civ., Sez. I, Ordinanza, 01/05/2026, n. 12239

Reg. CE n. 1493/1999-denominazioni di origine-indicazioni geografiche-vini-marchi anteriori notori-interferenza-decettività-non ingannevolezza-nullità-non proteggibilità-organizzazione comune del mercato vitivinicolo-TRIPS-Convenzione di Parigi-Accordo di Madrid-disciplina speciale-completezza normativa

Nel sistema del reg. CE n. 1493/1999, la disciplina di cui all'allegato VII, sezione F, par. 2, in materia di interferenza tra denominazioni di origine/indicazioni geografiche dei vini e marchi anteriori notori ha carattere di completezza e assorbe ogni profilo di decettività derivante dalla notorietà del marchio anteriore. Non è pertanto configurabile, per le denominazioni vitivinicole rientranti in detto regime, un'ulteriore causa di nullità o non proteggibilità fondata sul principio generale di non ingannevolezza, né possono essere invocate, a tal fine, disposizioni internazionali (TRIPS, Convenzione di Parigi, Accordo di Madrid) o norme settoriali estranee all'organizzazione comune del mercato vitivinicolo.

T.R.G.A. Trentino-Alto Adige Bolzano, 02/02/2026, n. 23

Filiera corta-filiera lunga-criteri ambientali minimi-CAM-materia agricola primaria-approvvigionamento-prodotti con più ingredienti-ingrediente principale-peso-denominazione del prodotto-sostenibilità ambientale

Nella logica della filiera non può dirsi prodotto da "filiera corta" quello realizzato con una materia agricola primaria proveniente da una filiera lunga, dettando i criteri ambientali minimi (CAM) una regola di approvvigionamento. Secondo i criteri ambientali minimi, per i prodotti con più ingredienti, si guarda all'ingrediente, vale a dire la materia agricola primaria più rappresentativa in termini di peso.

AMBIENTE

Corte giustizia Unione Europea, Sez. V, Sentenza, 16/04/2026, C-58/24

Rinvio pregiudiziale – Ambiente – Direttiva 92/43/CEE – Conservazione degli habitat naturali e seminaturali e della flora e della fauna selvatiche – Articolo 12 – Regime di rigorosa tutela di talune specie animali – Articolo 16 – Decisione di concedere una deroga in previsione di una domanda di permesso di costruire per un progetto rientrante nell'ambito di applicazione della direttiva 2011/92/UE – Articolo 11 – Convenzione di Aarhus – Articolo 9 – Autonomia procedurale – Principi di equivalenza e di effettività – Decisione di deroga qualificata come atto giuridico autonomo – Norme procedurali che prevedono un termine di tre mesi per chiedere l'annullamento di un'autorizzazione di deroga

L'articolo 11 della direttiva 2011/92/UE del Parlamento europeo e del Consiglio, del 13 dicembre 2011, concernente la valutazione dell'impatto ambientale di determinati progetti pubblici e privati, come modificata dalla direttiva 2014/52/UE del Parlamento europeo e del Consiglio, del 16 aprile 2014, letto alla luce dell'articolo 9 della convenzione sull'accesso alle informazioni, la par-

tecipazione del pubblico ai processi decisionali e l'accesso alla giustizia in materia ambientale, firmata ad Aarhus il 25 giugno 1998 e approvata a nome della Comunità europea con decisione 2005/370/CE del Consiglio, del 17 febbraio 2005, e dell'articolo 47 della Carta dei diritti fondamentali dell'Unione europea, dev'essere interpretato nel senso che esso non osta a una norma prevista dal diritto di uno Stato membro secondo la quale un ricorso di annullamento di un'autorizzazione di deroga, che sia stata rilasciata ai sensi dell'articolo 16 della direttiva 92/43/CEE del Consiglio, del 21 maggio 1992, relativa alla conservazione degli habitat naturali e seminaturali e della flora e della fauna selvatiche, e che rientri nel processo di autorizzazione di un progetto ai sensi dell'articolo 1, paragrafo 2, lettera a), della direttiva 2011/92, come modificata dalla direttiva 2014/52, deve essere proposto dal pubblico interessato entro un termine di tre mesi dal momento in cui tale pubblico è venuto a conoscenza o avrebbe potuto ragionevolmente venire a conoscenza della deroga, purché una tale norma giuridica non sia meno favorevole di quelle che riguardano ricorsi analoghi di natura interna (principio di equivalenza) e non renda in pratica impossibile o eccessivamente difficile l'esercizio dei diritti conferiti dall'ordinamento giuridico dell'Unione (principio di effettività).

T.A.R. Campania Napoli, Sez. III, Sentenza, 22/04/2026, n. 2573

Valutazione di incidenza-art. 6 direttiva 92/43/CEE-direttiva Habitat-natura preventiva-titolo abilitativo-assenso amministrativo-posteriorità-forma postuma-habitat tutelati-specie tutelate-degrado-perturbazione significativa-sosta stagionale-interesse pubblico-misura propedeutica

La Valutazione di incidenza, quale misura attuativa dell'art. 6 della direttiva 92/43/CEE ("Habitat"), ha natura preventiva e propedeutica rispetto al rilascio di qualunque titolo abilitativo o assenso amministrativo: essa deve precedere le determinazioni conclusive dell'amministrazione e non può essere utilmente svolta in forma postuma; è sufficiente la mera possibilità che l'intervento, anche senza opere ed anche se finalizzato a esigenze di interesse pubblico (come la sosta stagionale), causi un degrado o una perturbazione significativa degli habitat o delle specie tutelate.

T.A.R. Puglia Lecce, Sez. I, Sentenza, 18/03/2026, n. 416

VIA statale-impianti agrivoltaici-MASE-termini perentori-art. 25 comma 7 D.Lgs. n. 152/2006-inerzia-amministrazioni coinvolte-Ministero della Cultura-parere in sede di concerto-silenzio assenso-art. 17-bis L. n. 241/1990-procedimenti pluristrutturati-potere sostitutivo-art. 25 comma 2-quater D.Lgs. n. 152/2006-diniego VIA-illegittimità

In materia di VIA statale per impianti agrivoltaici, il Ministero dell'Ambiente e della Sicurezza Energetica è tenuto a concludere il procedimento nei termini perentori di cui all'art. 25, comma 7, D.Lgs. n. 152/2006, anche in presenza di inerzia delle altre amministrazioni coinvolte; la mancata espressione del parere del Ministero della Cultura, richiesto in sede di concerto, non legittima il diniego del provvedimento di VIA, dovendosi applicare, in via generale, il meccanismo del silenzio assenso ex art. 17-bis L. n. 241/1990, applicabile ai procedimenti "pluristrutturati" anche in combinazione con il potere sostitutivo di cui all'art. 25, comma 2-quater, D.Lgs. n. 152/2006.

BOSCHI

Cons. Stato, Sez. VI, Sentenza, 03/06/2026, n. 4431

Superficie boscata-vincolo paesaggistico-riduzione non autorizzata-illecito paesaggistico-rimessione in pristino-art. 167 D.Lgs. n. 42/2004-accertamento di compatibilità paesaggistica-comma 4-catalogo tassativo-opere edilizie-manufatti-trasformazione del suolo-suolo boschivo-obbligatorietà

La riduzione non autorizzata di superficie boscata assoggettata a vincolo paesaggistico integra un illecito per il quale, ai sensi dell'art. 167 del D.Lgs. n. 42/2004, è obbligatoria la rimessione in pristino, senza possibilità di accertamento di compatibilità paesaggistica, trattandosi di fattispecie non rientrante nel catalogo tassativo di cui al comma 4, riferito essenzialmente a opere edilizie su manufatti e non a trasformazioni di suolo boschivo.

Cons. Stato, Sez. IV, Sentenza, 10/03/2026, n. 1936

Vincolo paesaggistico-art. 142 comma 1 lett. g) D.Lgs. n. 42/2004-nozione di bosco-D.Lgs. n. 34/2018-artt. 3 e 4 D.Lgs. n. 34/2018-art. 4 L.R. Lazio n. 39/2002-nozione sostanziale-sistema vivente complesso-autorigenerazione-stabilità del paesaggio-radure-limiti dimensionali-vegetazione forestale-coltura agraria-continuità del bosco-imboschimento artificiale-monocoltura artificiale-inserti artefatti-copertura forestale-fauna selvatica-antropizzazione-provvedimento certativo-efficacia ex tunc-autorità amministrativa competente

Ai fini dell'applicazione del vincolo paesaggistico ex art. 142, comma 1, lett. g), D.Lgs. n. 42/2004, la nozione normativa di "bosco" - oggi desumibile dagli artt. 3 e 4 del D.Lgs. n. 34/2018 e, in ambito regionale, dall'art. 4 della L.R. Lazio n. 39/2002 - deve essere integrata da una

nozione sostanziale, che richiede l'esistenza di un sistema vivente complesso, tendenzialmente permanente, idoneo ad autorigenerarsi e costituente elemento stabile e caratteristico del paesaggio; in tale ottica, la presenza di radure inferiori ai limiti dimensionali di legge, intercluse tra lembi di vegetazione forestale e non destinate in modo continuativo a coltura agraria, non interrompe la continuità del bosco, ma ne costituisce parte integrante o area ad esso assimilata.
Ai fini della sussistenza del vincolo paesaggistico ex lege, dalla nozione sostanziale di bosco vanno esclusi gli insiemi arborati che non costituiscono elementi propri e tendenzialmente stabili della forma del territorio, quand'anche di imboschimento artificiale, ma che rispetto ad essa costituiscono inserti artefatti o naturalmente precari. In altri termini, la copertura forestale, necessaria per ritenere sussistente un bosco, deve costituire un sistema vivente complesso, non caratterizzato da una monocoltura artificiale, di apparenza non artefatta e deve essere tendenzialmente permanente.
La radura non è un luogo diverso dal bosco, dato che quest'ultimo può ben essere caratterizzato dalla presenza di porzioni di area coperte da alberature e porzioni di area sprovviste delle stesse. Una diversa interpretazione, infatti, non consentirebbe la tutela di tutti gli altri interessi pubblici, che motivano il divieto di antropizzazione di detti territori, quale ad esempio l'interesse alla tutela della fauna selvatica, che evidentemente necessita per la sua vita non solo di aree interamente boscate, ma anche di radure.
Il vincolo paesaggistico ex lege di cui all'art. 142, c. 1, lett. g), del D.Lgs. n. 42/2004 relativo alle aree boscate presuppone, a monte, la sussistenza in natura del bosco così come definito dal D.Lgs. n. 34/2018 e, a valle, in ragione della natura del vincolo, il provvedimento certativo adottato dall'autorità amministrativa competente che ne attesti con efficacia ex tunc l'effettiva esistenza.

T.A.R. Puglia Lecce, Sez. I, Sentenza, 25/02/2026, n. 301
Bosco-vincolo boschivo-valutazione della superficie-particelle catastali-proprietà privata-contesto complessivo-bene paesaggistico-vincolo forestale-elusione del vincolo-frazionamento-rilievi dimensionali-esclusione dal vincolo-superficie sottoposta a vincolo
Per la valutazione dei presupposti richiesti dalla legge per qualificare un'area come bosco occorre esaminare l'intera superficie sottoposta a vincolo boschivo e non le singole particelle di proprietà dell'interessato, che non vanno considerate avulse dall'intero contesto. Considerare esclusivamente le particelle del proprietario dell'area, infatti, sortirebbe l'effetto di suddividere le aree a bosco in tante piccole porzioni sulle quali effettuare rilievi finalizzati alla loro esclusione dal bene paesaggistico bosco, eludendo il vincolo forestale complessivo.

CACCIA E PESCA

Cons. Stato, Sez. VI, Sentenza, 17/02/2026, n. 1228
Fondo chiuso-art. 15 comma 8 L. n. 157/1992-art. 37 L.R. Lombardia n. 26/1993-divieto di esercizio venatorio-delimitazione materiale-muro-rete metallica-altezza minima-chiusura oggettiva-comunicazione alla Regione-tabellazione-funzione pubblicitaria-adempimenti formali-operatività del divieto-sussistenza oggettiva
La nozione di "fondo chiuso" ai sensi dell'art. 15, comma 8, della L. n. 157 del 1992, è desunta dalla presenza di una delimitazione materiale idonea a impedire l'accesso, mentre gli adempimenti di comunicazione e tabellazione alla Regione hanno funzione meramente pubblicitaria e non incidono sulla sussistenza del divieto di esercizio venatorio.
Il divieto di esercizio venatorio nei fondi chiusi previsto dall'art. 15, comma 8, della L. n. 157 del 1992 e dall'art. 37 della L.R. Lombardia n. 26 del 1993 è subordinato esclusivamente alla sussistenza oggettiva della chiusura materiale del fondo stessa (muro, rete metallica o altra effettiva chiusura di altezza non inferiore a metri 1,20), senza che sia necessaria la preventiva notificazione alla Regione o l'apposizione di adeguate tabellazioni per l'operatività del divieto.

Cons. Stato, Sez. VI, Sentenza, 03/02/2026, n. 895
Fondo agricolo-attività venatoria-sottrazione volontaria-ragioni etiche-ragioni morali-art. 15 comma 4 L. n. 157/1992-pianificazione faunistico-venatoria-delibere regionali-ipotesi tassative-limitazione del diritto-proprietario del fondo-illegittimità
Il diritto nazionale italiano prevede che la sottrazione del fondo agricolo dall'attività venatoria possa essere richiesta dal proprietario anche per ragioni etiche e morali, purché non ostacoli l'attuazione della pianificazione faunistico-venatoria (art. 15, comma 4, L. n. 157 del 1992). Le delibere regionali non possono limitare tale diritto con ipotesi tassative di sottrazione.

T.A.R. Lazio Roma, Sez. IV, Sentenza, 20/05/2026, n. 9340
Incompetenza-Ufficio Circondariale Marittimo-Ministero delle Infrastrutture e dei Trasporti-attrezzo da pesca-licenza di pesca-Ministero dell'Agricoltura della Sovranità Alimentare e delle Foreste-D.M. 26 luglio 1995-titoli abilitativi alla pesca-limitazione territoria-

le-riparto di competenze-vizio di incompetenza-provvedimento illegittimo
È affetto da vizio di incompetenza il provvedimento con cui un Ufficio Circondariale Marittimo, appartenente al Ministero delle Infrastrutture e dei Trasporti, limita territorialmente l'impiego di un attrezzo da pesca già autorizzato da licenza rilasciata dal Ministero dell'Agricoltura, della Sovranità Alimentare e delle Foreste, atteso che, ai sensi del D.M. 26 luglio 1995, artt. 2 ss., la competenza al rilascio e alla disciplina dei titoli abilitativi alla pesca è riservata a quest'ultimo Dicastero.

T.A.R. Abruzzo Pescara, Sez. I, Sentenza, 11/05/2026, n. 254
Esclusione dalla caccia-fondo agricolo-art. 10 comma 3 L. n. 157/1992-territorio agro-silvo-pastorale-quota 20-30 per cento-protezione della fauna selvatica-soglia minima di tutela-limite massimo-diniego di esclusione-automatismo-interesse pubblico-conservazione della fauna-illegittimità
In tema di esclusione dei fondi dall'attività venatoria, l'art. 10, comma 3, l. 11 febbraio 1992, n. 157 - che destina "una quota dal 20 al 30 per cento" del territorio agro-silvo-pastorale regionale alla protezione della fauna selvatica - non fissa un limite massimo invalicabile di aree sottratte alla caccia, ma individua una soglia minima di tutela, che può essere superata dal legislatore e dall'amministrazione in funzione dell'interesse pubblico primario alla conservazione della fauna. Ne consegue l'illegittimità del diniego di esclusione di un fondo dall'attività venatoria motivato in via automatica sul mero raggiungimento della soglia del 30%.

T.A.R. Umbria Perugia, Sez. I, Sentenza, 03/02/2026, n. 39
Ambiti Territoriali di Caccia-ATC-Comitato di Gestione-nomina del Presidente-giurisdizione ordinaria-giudice ordinario-organizzazione interna-diritto privato-natura pubblicistica-funzioni pubbliche-dimensione privatistica-riparto di giurisdizione
Le controversie riguardanti gli atti di nomina del Presidente del Comitato di Gestione degli Ambiti Territoriali di Caccia (ATC), in quanto afferenti a questioni di organizzazione interna e di diritto privato, devono essere devolute alla giurisdizione del Giudice Ordinario. A tale riguardo, non rileva la natura pubblicistica delle funzioni svolte dall'ATC, ma la dimensione privatistica dell'attività contestata.

T.A.R. Liguria Genova, Sez. II, Sentenza, 20/01/2026, n. 59
Caccia in deroga-specie protette-fringuello-storno-art. 9 comma 1 lett. c) Direttiva 2009/147/CE-tradizione venatoria regionale-impiego misurato-illegittimità-uccisione-tutela degli uccelli-deroga al divieto di caccia-giustificazione della deroga
La caccia in deroga alle specie protette fringuello (Fringilla coelebs) e storno (Sturnus vulgaris) ai sensi dell'articolo 9, comma 1, lett. c), della Direttiva 2009/147/CE è illegittima se motivata dalla volontà di salvaguardare una tradizione venatoria regionale. Tale tradizione, per quanto radicata nel territorio, non può giustificare un impiego misurato di uccelli protetti mediante uccisione, che esula dal concetto di "impiego misurato".

CONTRATTI AGRARI

Cass. civ., Sez. III, Ordinanza, 09/06/2026, n.
Esecuzione forzata-art. 2923 c.c.-contratto di locazione-affitto agrario-accordi modificativi-migliorie-compensazione dei canoni-sinallagma contrattuale-opponibilità-procedura esecutiva-aggiudicatario-data certa-pignoramento-anteriorità della data certa
In tema di esecuzione forzata, l'art. 2923 c.c. si applica non solo ai contratti di locazione, ma anche ai contratti di affitto agrario e ai relativi accordi modificativi, inclusi quelli che disciplinano il regime delle migliorie e la compensazione dei canoni, i quali - incidendo sul sinallagma contrattuale e sulle obbligazioni economiche dell'affittuario - sono soggetti, ai fini dell'opponibilità alla procedura esecutiva e all'aggiudicatario, al requisito della data certa anteriore al pignoramento.

Cass. civ., Sez. III, Ordinanza, 12/06/2026, n. 19483
Affitto di fondo rustico-natura agraria-oggetto del contratto-titolo negoziale-assistenza sindacale-art. 45 L. n. 203/1982-uso unilaterale-ricovero di animali-produzione agricola-sezione specializzata agraria-competenza funzionale inderogabile-qualificazione del contratto
In tema di affitto di fondo rustico, la natura agraria del rapporto va desunta dall'oggetto del contratto e dal titolo negoziale – nella specie, contratto espressamente qualificato come affitto di fondo rustico stipulato con assistenza sindacale ex art. 45 L. n. 203/1982 – e non può essere modificata dall'uso unilaterale successivo del bene da parte dell'affittuario (ad es. ricovero di animali non destinati alla produzione), sicché la competenza funzionale della Sezione specializzata agraria resta inderogabile.

Cass. civ., Sez. V, Ordinanza, 30/05/2026, n. 16945
IVA-contratto di soccida-soccidante-conferimento di mangimi-conferimento di animali-mezzi produt-

tivi-apporto associativo-cessione di beni-titolo oneroso-campo di applicazione IVA-art. 36 D.P.R. n. 633/1972-attività separate-passaggi interni-valore normale-imponibile-esclusione dall'imposta
In tema di IVA, il conferimento di mangimi, animali o altri mezzi produttivi da parte del soccidante nell'ambito di un contratto di soccida integra un apporto al rapporto associativo e non una cessione di beni a titolo oneroso; ne consegue che tali operazioni restano fuori dal campo di applicazione dell'imposta, con inapplicabilità dell'art. 36 del D.P.R. n. 633/1972 in materia di passaggi interni tra attività separate, non potendosi assumere il valore normale quale parametro di determinazione dell'imponibile.

Cass. civ., Sez. III, Sentenza, 19/05/2026, n. 15067
Contratti agrari - Prelazione e riscatto - Prelazione - Preliminare di vendita di fondo rustico - Efficacia subordinata all'esercizio del diritto di prelazione del mezzadro-colono - Individuazione dell'evento risolutivo del rapporto - Criteri
In materia di preliminare di vendita di fondo rustico, sottoposto alla condizione del mancato esercizio da parte del mezzadro-colono del diritto di prelazione, in base al disposto dell'art. 8, della l. n. 590 del 1965, la condizione cui è subordinata risolutivamente l'efficacia del preliminare non si verifica con il solo esercizio del diritto di prelazione, essendo necessario, da parte del prelazionante, anche il rispetto dei termini legali di pagamento del prezzo, a meno che, dal concreto regolamento di interessi posto in essere dagli stipulanti, non emerga che essi hanno inteso ricondurre il definitivo caducarsi del preliminare al solo esercizio del diritto di prelazione.

Cass. civ., Sez. III, Sentenza, 14/05/2026, n. 14260
Contratti agrari - Affitto - A coltivatore diretto - Prova della qualità di coltivatore diretto - Iscrizione in elenchi - Sufficienza - Esclusione - Prova dell'obiettivo svolgimento dell'attività di coltivazione del fondo - Necessità - Qualità - Accertamento - Poteri del giudice di merito - Sindacato in sede di legittimità - Limiti.
L'accertamento della qualità di coltivatore diretto in capo ad un soggetto (parte di una controversia agraria) è demandato al discrezionale apprezzamento del giudice di merito, incensurabile in sede di legittimità ove sorretto da motivazione adeguata, fondata su esatti criteri logico - giuridici.

Cassazione civ., sez. III, sentenza, 12/03/2026, n. 5647
Affitto agrario-fondo rustico-comproprietari-comunione-sostituzione automatica della clausola-durata legale-durata quindicennale-art. 45 L. n. 203/1982-art. 58 L. n. 203/1982-straordinaria amministrazione-art. 1108 comma 3 c.c.-consenso unanime-nullità-inefficacia-inopponibilità-comproprietario non consenziente-gestione di affari altrui-conduttore
Qualora un contratto di affitto agrario di fondo rustico, stipulato da uno solo dei comproprietari, assuma per effetto della sostituzione automatica della clausola che stabilisca una durata inferiore a quella di legge *ex* articoli 45e 58 della legge n. 203 del 1982 la durata legale quindicennale, l'atto deve qualificarsi come atto di straordinaria amministrazione ai sensi dell'articolo 1108, comma 3, del codice civile; ne consegue che la mancanza del consenso unanime dei partecipanti alla comunione non determina la nullità del contratto, ma la sua inefficacia (inopponibilità) nei confronti del comproprietario che non abbia prestato il consenso, restando il contratto valido ed efficace tra il comproprietario stipulante e il terzo conduttore, secondo lo schema della gestione di affari altrui.

Cassazione civ., sez. III, sentenza, 26/01/2026, n. 1788
Riscatto agrario-fondo rustico-compratore-venditore-confinante retraente-evizione-garanzia per evizione-art. 1483 c.c.-art. 1479 c.c.-risarcimento del danno-rimborso del prezzo-retraente-diritti del compratore
Il compratore del fondo rustico che ne subisce il riscatto da parte del confinante ha diritto nei confronti del venditore, secondo le norme dettate dagli articoli 1483 e 1479 del codice civile e in base alle regole che disciplinano la garanzia per l'evizione, al risarcimento del danno, ma non anche al rimborso del prezzo pagato, che gli è dovuto dal retraente

CONSORZI

Cass. civ., Sez. V, Ordinanza, 31/03/2026, n. 7801
Contributo consortile-consorzio di bonifica-perimetro di contribuenza-piano di classifica-presunzione di beneficio-beneficio di bonifica-prova contraria-vantaggio fondiario-consorziato-accertamento di fatto-giudice di merito-sindacato di legittimità-art. 360 n. 5 c.p.c.-motivazione-vizi estremi
Ai fini dell'assoggettamento dei fondi al contributo consortile, l'inclusione del terreno nel perimetro di contribuenza risultante dal piano di classifica approvato dal competente Consorzio integra una presunzione di sussistenza del beneficio di bonifica, imponendo al consorziato l'onere di fornire prova contraria dell'assenza di vantaggio fondiario; l'accertamento del giudice di merito sulla mancata dimostrazione di tale prova contraria costituisce apprezzamento di fatto, insindacabile in sede

di legittimità, ove adeguatamente motivato e immune dai vizi estremi delineati dall'art. 360, n. 5, c.p.c. nel testo novellato.

Cass. civ., Sez. V, Ordinanza, 31/03/2026, n. 7793
Contributi consortili-bonifica-perimetro consortile-piano di classifica-autorità regionale-presupposto impositivo-presunzione di beneficio-beneficio diretto e specifico-inversione dell'onere probatorio-contribuente-impugnazione amministrativa-contestazione giudiziale-beneficio fondiario-criteri di applicazione-inesecuzione delle opere-non funzionamento delle opere-prova contraria-consorzio-esonero dall'onere probatorio
In tema di contributi consortili di bonifica, la mera inclusione del fondo nel perimetro consortile e nel piano di classifica, approvato dall'autorità regionale, non comporta di per sé la definitività del presupposto impositivo, ma soltanto una presunzione di sussistenza del beneficio diretto e specifico in favore del fondo, idonea a determinare un'inversione dell'onere probatorio. Ne consegue che il contribuente, anche senza aver impugnato il piano di classifica in sede amministrativa, è sempre legittimato a contestare in giudizio l'esistenza del beneficio fondiario e i criteri di applicazione del piano, potendo fornire la prova contraria mediante la dimostrazione dell'inesecuzione o del non funzionamento delle opere previste, mentre il consorzio è esonerato dall'onere iniziale di provare il beneficio in ragione della suddetta presunzione.

Cass. civ., Sez. V, Ordinanza, 31/03/2026, n. 7792
Consorzi di bonifica-conguagli-piano di riordino fondiario-ricomposizione fondiaria-maggior valore dei terreni-maggiore estensione dei terreni-corrispettivo patrimoniale-indennizzo-contributi consortili-natura tributaria-riparto di giurisdizione-Sezioni Unite-rimessione-art. 374 comma 2 c.p.c.-qualificazione giuridica-spese pubbliche
In tema di consorzi di bonifica, la controversia avente ad oggetto i c.d. "conguagli" dovuti dai consorziati a seguito di piano di riordino fondiario - prospettati dal Consorzio come corrispettivo/indennizzo patrimoniale, fondato sul maggior valore o sulla maggiore estensione dei terreni conseguenti alla ricomposizione fondiaria, e non come contributi imposti a copertura delle spese pubbliche dell'ente - pone una questione di giurisdizione diversa da quella già esaminata dalle Sezioni Unite in materia di contributi consortili di bonifica in senso proprio, sicché la relativa qualificazione (tributaria o meno) e il conseguente riparto di giurisdizione richiedono rimessione alle Sezioni Unite ai sensi dell'art. 374, comma 2, c.p.c.

Cass. civ., Sez. III, Ordinanza, 31/03/2026, n. 7758
Giurisdizione ordinaria-organismo collettivo di difesa-produzioni agricole-personalità giuridica di diritto privato-agente della riscossione-convenzione di appalto-riscossione coattiva-ruolo-contributi consortili-natura privatistica-natura pubblicistica-tributi-maneggio di denaro pubblico-Corte dei conti-riparto di giurisdizione-soci
Appartiene alla giurisdizione del giudice ordinario la controversia tra un organismo collettivo di difesa delle produzioni agricole, avente personalità giuridica di diritto privato, e l'agente della riscossione incaricato in base a convenzioni di appalto di servizi della riscossione, anche coattiva e mediante ruolo, dei contributi consortili dovuti dai soci: né la natura privatistica dell'ente, né quella privata dei contributi consortili si trasformano in pubblicistiche per il solo fatto che la riscossione avvenga con le modalità previste per i tributi, mancando, pertanto, il presupposto del "maneggio di denaro pubblico" necessario a radicare la giurisdizione della Corte dei conti.

Cass. civ., Sez. V, Ordinanza, 05/02/2026, n. 2500
Contributi consortili-presupposto impositivo-beneficio fondiario specifico-fruizione-fruibilità-attività di bonifica-miglioramento dell'immobile-opere di difesa idraulica-manutenzione-imposizione tributaria-consorziato-periodo di riferimento
In materia di contributi consortili, il presupposto impositivo è basato sull'esistenza di un beneficio fondiario specifico, che può consistere non solo nella fruizione, ma anche nella fruibilità concreta dell'attività di bonifica, in grado di migliorare l'immobile del consorziato. Il beneficio, anche se intrinseco alle opere di difesa idraulica del territorio, è idoneo a giustificare l'imposizione tributaria anche se non direttamente connesso ad interventi di manutenzione specifici nel periodo di riferimento.

IMPRESA, MERCATO E LAVORO

Corte giustizia Unione Europea, Sez. II, Sentenza, 29/01/2026, C-311/24
Rinvio pregiudiziale – Agricoltura – Concorrenza sleale – Pratiche commerciali sleali – Direttiva (UE) 2019/633 – Divieto – Articolo 3, paragrafo 1, lettera d) – Richiesta di pagamento non connessa alla vendita di prodotti agricoli e alimentari del fornitore – Articolo 6, paragrafo 1, primo comma, lettera e) – Potere di imporre sanzioni pecuniarie – Qualificazione come "infrazione unica" conferita a diverse pratiche commerciali sleali vietate che dà luogo all'imposizione di una sola sanzione pecuniaria – Principio del "ne bis in

idem" – Normativa nazionale che prevede il massimale della sanzione pecuniaria
L'articolo 6, paragrafo 1, primo comma, lettera e), della direttiva (UE) 2019/633 del Parlamento europeo e del Consiglio, del 17 aprile 2019, in materia di pratiche commerciali sleali nei rapporti tra imprese nella filiera agricola e alimentare, in combinato disposto con l'articolo 6, paragrafo 1, secondo comma, di tale direttiva, deve essere interpretato nel senso che esso non osta a una normativa nazionale che prevede che più richieste di pagamento non connesse alla vendita di prodotti agricoli e alimentari, ai sensi dell'articolo 3, paragrafo 1, lettera d), di detta direttiva, e inviate contemporaneamente da un acquirente a diversi fornitori per un unico motivo debbano essere qualificate congiuntamente come infrazione unica, che dà luogo all'irrogazione di un'unica sanzione pecuniaria, la quale ha un limite massimo stabilito a un importo fisso, a condizione che l'autorità nazionale di contrasto o il giudice nazionale che ha l'incarico di sanzionare tale infrazione goda del potere discrezionale necessario per fissare una sanzione pecuniaria che sia efficace, proporzionata e dissuasiva e che tenga conto della natura, della durata, della frequenza e della gravità di detta infrazione.

Cassazione civ., sez. trib., sentenza, 20/04/2026, n. 10325
Allevamento di cavalli da corsa finalizzato all'attività agonistica - Attività agricola - Esclusione - Fattispecie.
In tema di imposte sui redditi, l'allevamento di cavalli da corsa finalizzato all'attività agonistica, per la sua autonomia rispetto allo sfruttamento a fini agricoli del terreno e dell'annessa scuderia, non può essere qualificato come attività agricola ai sensi dell'art. 2135 c.c., richiedendo un complesso di conoscenze tecniche estranee al settore propriamente agricolo. (Nella specie, la S.C. ha confermato la sentenza impugnata che, dopo aver ritenuto non agricola la suddetta attività di allevamento di cavalli con finalità agonistica, aveva ritenuto legittima la ripresa a tassazione, quali ricavi d'impresa, dei premi "al traguardo" versati dall'UNIRE, previa detrazione dei costi accertati in sede di verifica).

Cass. civ., sez. lav., sentenza, 1/04/2026, n. 8169
Pannelli fotovoltaici-produzione di energia-attività agricola-prevalenza-art. 1 comma 423 L. n. 266/2005-regime di favore-impresa agricola-attività connesse-vocazione agricola-snaturamento dell'impresa-qualificazione dell'attività-ratio normativa
Se l'utilizzo del fondo per installazione di pannelli e produzione di energia fotovoltaica diviene prevalente rispetto all'utilizzo per l'attività agricola, non si rinviene la *ratio* dell'articolo 1, comma 423, della legge 266/05, volta a riconoscere un regime di favore per l'impresa agricola pur in presenza dell'esercizio di attività connesse, purché queste ultime non snaturino la stessa impresa, contraddicendone la vocazione agricola.

Cassazione civ., sez. I, sentenza, 9/03/2026, n. 5268
Esenzione dal fallimento-imprenditore agricolo-trasformazione di prodotti agricoli-commercializzazione di prodotti agricoli-attività connesse-art. 2135 comma 3 c.c.-prevalenza dei prodotti propri-prodotti di terzi-onere della prova-art. 2697 comma 2 c.c.-qualificazione dell'attività-condizioni di esenzione
L'esenzione dal fallimento dell'imprenditore agricolo, che eserciti anche attività di trasformazione e commercializzazione di prodotti agricoli, postula la dimostrazione della sussistenza delle condizioni per ricondurre tale attività nell'ambito di quelle connesse, di cui all'articolo 2135, comma 3, del codice civile e, in particolare, che essa abbia come oggetto prevalente prodotti propri e non ceduti o coltivati da terzi; l'onere della prova di tali condizioni va posto a carico di chi le invochi, in ossequio all'articolo 2697, comma 2, del codice civile.

T.A.R. Lazio Roma, Sez. IV quater, Sentenza, 15/05/2026, n. 8991
Cura e ricovero di animali d'affezione-cod. ATECO 96.09.04-attività agricola-art. 2135 c.c.-ciclo produttivo agricolo-coltivazione del fondo-allevamento-produzione agricola-connessione-requisito di esclusività-impresa cedente-lex specialis-qualificazione dell'attività
Il servizio di cura e ricovero degli animali d'affezione (cod. ATECO 96.09.04) non rientra nella nozione di attività agricola di cui all'art. 2135 c.c., poiché non è inserito nel ciclo produttivo agricolo né è connesso alla coltivazione del fondo o all'allevamento orientato alla produzione; tale attività, se svolta dall'impresa cedente, esclude la ricorrenza del requisito di esclusività dell'attività agricola richiesto dalla lex specialis.

T.A.R. Veneto Venezia, Sez. IV, Sentenza, 25/03/2026, n. 649
Contributi INAIL-avviso pubblico ISI 2023-società agricola-esclusione dal finanziamento-coltivatore diretto-gestione agricola INPS-socio lavoratore-Gestione Artigiani INPS-obblighi contributivi-art. 7 avviso pubblico-iscrizione previdenziale-attività agricola-art. 1 comma 5-bis D.Lgs. n. 99/2004-requisiti di ammissione-regolarità contributiva
In tema di contributi INAIL di cui all'avviso pubblico ISI 2023, è legittima l'esclusione dal finanziamento della società agricola che, pur avendo un socio coltivatore

diretto regolarmente iscritto alla gestione agricola INPS, indichi quale socio lavoratore anche un soggetto iscritto ad una diversa gestione (nella specie, Gestione Artigiani INPS) e non alla gestione previdenziale per l'agricoltura, in quanto l'art. 7 dell'avviso richiede, a pena di esclusione, che tutti i soci che svolgono attività lavorativa a favore dell'impresa siano in regola con gli obblighi contributivi "in proprio" e "con riferimento all'attività di impresa oggetto del finanziamento", requisito da intendersi, per le imprese agricole, come iscrizione alla gestione agricola INPS, in coerenza con l'art. 1, comma 5-bis, d.lgs. 29 marzo 2004, n. 99.

Corte appello Ancona, sez. I, sentenza, 30/01/2026, n. 122

Impresa familiare agricola-comunione tacita familiare-famiglia colonica-art. 230-bis c.c.-comunanza di utili e perdite-convivenza-attività lavorativa comune-unico peculio-gestione informale-rendiconto-bisogni familiari-attività d'impresa-requisiti costitutivi

L'impresa famigliare agricola (comunione tacita familiare nell'esercizio dell'agricoltura - c.d. 'famiglia colonica') quale specie del più ampio genere dell'impresa familiare di ex art. 230-bis c.c. si fonda sui seguenti requisiti: 1. la comunanza di utili e perdite; 2. la convivenza dei partecipanti; 3. la comune attività lavorativa; 4. la formazione di un 'unico peculio', gestito senza particolari formalità ed obblighi di rendiconto e destinato a fornire i mezzi economici necessari ai bisogni della comunità familiare ed all'attività d'impresa.

PAESAGGIO

Corte cost., Sentenza, 27/04/2026, n. 57

Piano paesaggistico regionale-co-pianificazione-artt. 135 e 143 D.Lgs. n. 42/2004-parchi naturali-aree protette regionali-beni paesaggistici-art. 142 comma 1 lett. f) D.Lgs. n. 42/2004-riperimetrazione-riduzione della tutela-legge regionale-Ministero della Cultura-art. 9 Cost.-art. 117 comma 2 lett. s) Cost.-livelli di protezione paesaggistica-divieto di riduzione-illegittimità costituzionale-tutela del paesaggio

In presenza di un piano paesaggistico regionale co-pianificato ai sensi degli artt. 135 e 143 d.lgs. n. 42 del 2004, la Regione non può unilateralmente ridurre il perimetro di parchi naturali e aree protette regionali, che costituiscono beni paesaggistici ex art. 142, comma 1, lett. f), d.lgs. n. 42 del 2004, sottraendo porzioni di territorio alla tutela paesaggistica già recepita nel piano. Tale riperimetrazione "in peius", effettuata con legge regionale senza il coinvolgimento del Ministero della cultura nell'ambito della co-pianificazione, viola gli artt. 9 e 117, secondo comma, lett. s), Cost., giacché i livelli di protezione paesaggistica fissati in sede statale e nel piano paesaggistico possono essere solo incrementati e non ridotti dal legislatore regionale.

Cons. Stato, Sez. VI, Sentenza, 12/06/2026, n. 4729

Vincolo paesaggistico-corso d'acqua-art. 142 D.Lgs. n. 42/2004-relazione paesaggistica-beni culturali-area vincolata-compatibilità paesaggistica-contesto paesaggistico-impatto visivo-stazione radio base-edificio sacro-pregio storico-artistico-rapporto visivo-istruttoria-autorizzazione paesaggistica-illegittimità

In presenza di vincolo paesaggistico derivante da corso d'acqua ex art. 142 D.Lgs. n. 42/2004, l'obbligo di indicare nella relazione paesaggistica i beni culturali presenti nell'area vincolata non può essere interpretato in senso meramente restrittivo, limitandolo alla sola porzione di suolo materialmente occupata dall'intervento; al contrario, la valutazione di compatibilità deve estendersi all'impatto dell'opera sull'intero contesto paesaggistico di riferimento, includendo i beni culturali ivi ubicati e potenzialmente interferiti sul piano visivo. È pertanto illegittima l'autorizzazione che non tenga conto del rapporto visivo tra un impianto tecnologico di forte impatto (stazione radio base) e un vicino edificio sacro di rilevante pregio storico-artistico, se tale rapporto non sia stato neppure oggetto di istruttoria.

T.A.R. Puglia Lecce, Sez. I, Sentenza, 03/06/2026, n. 835

Classificazione urbanistica-zona C1-zona E2-area edificabile-paesaggi rurali-PPTR-pianificazione paesaggistica-pianificazione urbanistica-autonomia funzionale-art. 145 comma 3 D.Lgs. n. 42/2004-prevalenza delle prescrizioni paesaggistiche-strumenti urbanistici comunali-contrasto-inclusione nel contesto paesaggistico

La classificazione urbanistica di un'area come edificabile (zone C1 o E2) non esclude, di per sé, la legittima inclusione della medesima nel contesto paesaggistico "Paesaggi rurali" del PPTR, dovendo affermarsi l'autonomia funzionale della pianificazione paesaggistica rispetto a quella urbanistica e la prevalenza, ex art. 145, co. 3, d.lgs. n. 42/2004, delle prescrizioni paesaggistiche sui contrastanti strumenti comunali.

T.A.R. Toscana Firenze, Sez. III, Sentenza, 08/04/2026, n. 688

Parere negativo-Soprintendenza-autorizzazione paesaggistica-sostituzione edilizia-ampliamento volumetrico-pineta-Tombolo-Marina di Grosseto-vincolo paesaggistico puntuale-D.M. 27 marzo 1958-art. 142 com-

ma 1 lett. g) D.Lgs. n. 42/2004-PIT-PPR-consumo di suolo-formazione boschiva costiera-prescrizioni violate-elaborato 8/B-motivazione adeguata-legittimità
È legittimo il parere negativo della Soprintendenza sull'istanza di autorizzazione paesaggistica per intervento di sostituzione edilizia con significativo ampliamento volumetrico all'interno della pineta del Tombolo di Marina di Grosseto, area tutelata sia da vincolo paesaggistico puntuale (D.M. 27 marzo 1958) sia ope legis ex art. 142, comma 1, lett. g), D.Lgs. n. 42/2004, qualora il parere:.- richiami puntualmente i vincoli gravanti sull'area e la disciplina del PIT-PPR;.- descriva l'intervento e ne evidenzi l'incidenza in termini di nuovo consumo di suolo nella "formazione boschiva costiera";.- individui le prescrizioni del PIT violate (in specie, punto 12.3, lett. b, elaborato 8/B, e punti 2.c.1, 2.c.2, 4.c.1),.configurandosi così una motivazione adeguata e completa.

T.A.R. Sicilia Catania, Sez. II, Sentenza, 22/01/2026, n. 196
Valutazione di impatto ambientale-VIA-autorizzazione paesaggistica-autonomia procedimentale-interesse a ricorrere-giudizio negativo di compatibilità ambientale-art. 23 D.Lgs. n. 152/2006-componente paesaggistica-impatti sul territorio-procedimenti distinti-ricorso-decisione nel merito
La distinzione tra il procedimento di valutazione di impatto ambientale e quello di autorizzazione paesaggistica non preclude l'interesse alla decisione del ricorso contro l'autorizzazione paesaggistica, anche in presenza di un giudizio negativo di compatibilità ambientale ai sensi dell'art. 23 del D.Lgs. n. 152 del 2006. La valutazione di impatto ambientale, pur autonoma, può includere la componente paesaggistica per la complessività dell'esame degli impatti sul territorio.

PARCHI E AREE PROTETTE

Cons. Stato, Sez. IV, Sentenza, 13/05/2026, n. 3771
Parchi nazionali-delimitazione provvisoria-art. 34 comma 3 L. n. 394/1991-natura cautelare-elementi tecnico-scientifici-intesa con la Regione-partecipazione regionale-misure di salvaguardia-perimetrazione definitiva-art. 2 comma 7 L. n. 394/1991-fase provvisoria-anticipazione dell'intesa-illegittimità
In tema di parchi nazionali, la delimitazione provvisoria di cui all'art. 34, comma 3, L. 6 dicembre 1991, n. 394 ha natura cautelare ed è fondata esclusivamente su elementi conoscitivi e tecnico-scientifici; in tale fase non è richiesta alcuna intesa con la Regione, la cui partecipazione è limitata alla trasmissione dei dati e all'espressione del parere sulle misure di salvaguardia. L'intesa ex art. 2, comma 7, della medesima legge è necessaria solo per la perimetrazione definitiva e non può essere anticipata alla fase provvisoria.

T.A.R. Campania Napoli, Sez. VII, Sentenza, 04/03/2026, n. 1518
Parco Nazionale-Ente Parco-conferenza di servizi-convocazione-provvedimenti autorizzatori-silenzio-assenso-art. 44 comma 10 D.Lgs. n. 259/2003-titolo abilitativo-perfezionamento-mancata convocazione-area protetta-illegittimità
Quando l'area oggetto di intervento ricade nella perimetrazione di un Parco Nazionale, è necessario convocare il competente Ente Parco nella conferenza di servizi per l'adozione di provvedimenti autorizzatori. La mancata convocazione preclude la formazione del silenzio-assenso previsto dall'art. 44, comma 10, del D.Lgs. n. 259 del 2003, impedendo così il perfezionamento del titolo abilitativo.

PROPRIETÀ E PRELAZIONE

Cass. civ., Sez. III, Ordinanza, 17/03/2026, n. 5996
Riscatto agrario-art. 8 L. n. 590/1965-art. 7 L. n. 817/1971-omessa pronuncia-art. 112 c.p.c.-motivo di gravame-coltivazione diretta-coltivazione abituale-fondo confinante-biennio anteriore-compravendita-fatto costitutivo-diritto di prelazione-coltivatore diretto-giudice d'appello
In tema di riscatto agrario ex art. 8 L. n. 590/1965 e art. 7 L. n. 817/1971, integra violazione dell'art. 112 c.p.c. l'omessa pronuncia da parte del giudice d'appello sul motivo di gravame con cui si contesta la mancata prova della coltivazione diretta ed abituale del fondo confinante nel ben determinato biennio anteriore all'atto di compravendita, poiché il requisito del biennio costituisce fatto costitutivo specifico del diritto di prelazione/riscatto e non può ritenersi implicitamente scrutinato mediante una generica valutazione della qualità di coltivatore diretto.

Cass. civ., Sez. III, Ordinanza, 17/03/2026, n. 5990
Prelazione agraria-riscatto agrario-contratto di affitto agrario-terzo affittuario-contratto registrato-ostacolo legale-confinante coltivatore diretto-rogito notarile-traditio immediata-prova legale-atto pubblico-dichiarazioni delle parti-requisiti soggettivi del riscattante-triplo della capacità lavorativa-art. 8 comma 1 L. n. 590/1965-art. 31 L. n. 590/1965-fondi condotti-proprietà-enfiteusi-affitto-comodato-nucleo familiare-espansione della proprietà contadina

L'esistenza di un contratto di affitto agrario in corso a favore di terzi, validamente provata (nella specie tramite contratto registrato), costituisce ostacolo legale all'esercizio del diritto di prelazione e riscatto da parte del confinante coltivatore diretto; la clausola del rogito notarile che preveda la traditio immediata non ha efficacia di prova legale dell'inesistenza o cessazione del rapporto agrario, incidendo l'atto pubblico solo sulla provenienza e sulle attività svolte dal pubblico ufficiale, ma non sulla verità intrinseca delle dichiarazioni delle parti.
In tema di requisiti soggettivi del riscattante, ai fini dell'accertamento del requisito del "triplo della capacità lavorativa" ex art. 8, comma 1, L. n. 590/1965, il calcolo deve comprendere tutti i fondi stabilmente condotti dal coltivatore, a qualunque titolo (proprietà, enfiteusi, affitto o comodato). Tale norma va interpretata in combinato disposto con l'art. 31 della stessa legge, al fine di garantire che l'espansione della proprietà contadina sia proporzionata all'effettiva forza lavorativa del nucleo familiare.

Cass. civ., Sez. III, Ordinanza, 26/01/2026, n. 1676
Prelazione agraria-riscatto agrario-tassatività-stretta interpretazione-divieto di analogia-società agricole-art. 2 comma 3 D.Lgs. n. 99/2004-società di persone-coltivatore diretto-iscrizione-sezione speciale del registro delle imprese-società di capitali-esclusione-qualifica di coltivatore diretto
In tema di prelazione agraria, le ipotesi di prelazione e riscatto disciplinate dall'ordinamento giuridico devono considerarsi tassative e di stretta interpretazione, non essendo suscettibili di interpretazione estensiva o analogica.
Il diritto di prelazione agraria spetta alle sole società agricole aventi le caratteristiche descritte dall'art. 2, comma 3, D.Lgs. n. 99/2004, ossia dalle società agricole di persone in cui almeno la metà dei soci sia in possesso della qualifica di coltivatore diretto come risultante dall'iscrizione nella sezione speciale del registro delle imprese, ma non alle società agricole di capitali.

Cass. civ., Sez. III, Ordinanza, 23/01/2026, n. 1519
Diritto di prelazione e di riscatto - Riscatto - Riscatto agrario - Preliminare di vendita del fondo oggetto di prelazione - Acquisto del coltivatore confinante in epoca successiva alla stipula - Insussistenza del diritto di prelazione - Ragioni
Non compete il diritto di riscatto al proprietario coltivatore diretto del terreno confinante con il fondo offerto in vendita, qualora egli abbia acquistato la proprietà del detto terreno in epoca successiva alla stipulazione del preliminare di vendita relativo al fondo oggetto di riscatto, essendo in presenza di una situazione obbligatoria già definita in base ad un'attività negoziale legittima posta in essere dal proprietario del fondo allorquando il diritto di prelazione era insussistente.

Cons. Stato, Sez. IV, Sentenza, 16/03/2026, n. 2155
Riuso urbano-rigenerazione urbana-recupero edilizio-edifici rurali-attività agricola-cambio d'uso-uso residenziale-art. 36 L.R. Emilia-Romagna n. 24/2017-valore storico-architettonico-valore identitario-qualificazione del paesaggio-spopolamento-abbandono-presupposti applicativi-strumenti urbanistici comunali-vincoli urbanistici
L'art. 36 della L.R. Emilia-Romagna n. 24/2017, che promuove interventi di riuso e rigenerazione urbana e il recupero di edifici rurali non più funzionali all'attività agricola, non impone in via generalizzata l'assenso al cambio d'uso a residenziale: esso presuppone la presenza di immobili con riconosciuto valore storico-architettonico o identitario, interventi idonei a qualificare il paesaggio e contesti caratterizzati da fenomeni di spopolamento o abbandono; la mancanza di tali presupposti esclude che la norma possa essere invocata per superare i vincoli e le limitazioni dettati dagli strumenti urbanistici comunali.

T.A.R. Toscana Firenze, Sez. III, Sentenza, 24/03/2026, n. 571
Ruralità-fabbricato rurale-qualificazione catastale-catasto fabbricati-categoria A-rilievo fiscale-destinazione d'uso urbanistica-mutamento di destinazione-uso residenziale-titolo edilizio abilitativo-deruralizzazione-urbanizzazione-cambio di destinazione-stato legittimo-art. 9-bis comma 1-bis D.P.R. n. 380/2001
La perdita dei requisiti di ruralità di un fabbricato e la sua diversa qualificazione catastale (passaggio al catasto fabbricati in categoria A) hanno rilievo esclusivamente fiscale e di censimento e non comportano, di per sé, il mutamento della destinazione d'uso urbanistico da rurale a residenziale, che richiede comunque uno specifico titolo edilizio abilitativo; la deruralizzazione dell'area e la progressiva urbanizzazione del contesto non determinano automaticamente il cambio di destinazione del manufatto, né provano il suo "stato legittimo" in assenza di idoneo titolo ai sensi dell'art. 9-bis, comma 1-bis, D.P.R. n. 380/2001.

T.A.R. Sardegna Cagliari, Sez. I, Sentenza, 09/03/2026, n. 521
Aree agricole-fonti rinnovabili-idoneità per legge-art. 20 D.Lgs. n. 199/2021-perimetro di 500 metri-zone industriali-zone artigianali-zone commerciali-lett. c-quater)-lett. c-ter)-clausola residuale-disciplina speciale-installazione di impianti-rapporto tra disposizioni

Ai sensi dell'art. 20, D.Lgs. n. 199/2021, le aree agricole possono considerarsi "idonee per legge" all'installazione di impianti da fonti rinnovabili solo se ricomprese nel perimetro di 500 metri da zone industriali, artigianali o commerciali; la clausola di cui alla lett. c-quater) opera "fatto salvo" quanto previsto, tra l'altro, dalla lett. c-ter), sicché non è applicabile, in via residuale, alle aree agricole, per le quali vale la disciplina speciale di quest'ultima disposizione.

T.A.R. Lazio Roma, Sez. III, Sentenza, 17/02/2026, n. 3048

Impianto agrovoltaico-area idonea-D.Lgs. n. 199/2021-compatibilità ambientale-patrimonio culturale-patrimonio paesaggistico-diniego motivato-antropizzazione-relazioni funzionali storiche-contesto di riferimento-autorità competenti-valutazione di impatto-automatismo-alterazione del paesaggio

La localizzazione di un impianto agrovoltaico in un'area dichiarata idonea ai sensi del D.Lgs. n. 199 del 2021 non determina automaticamente una compatibilità ambientale. Le autorità competenti devono valutare l'interferenza del progetto con rilevanti aspetti del patrimonio culturale e paesaggistico, potendo esprimere un diniego motivato in ragione di una severa antropizzazione dell'area e dell'alterazione delle relazioni funzionali storiche del contesto di riferimento.

AESTIMUM
CENTRO STUDI DI ESTIMO E DI ECONOMIA TERRITORIALE - Ce.S.E.T.
Vol. 88 – 2026

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