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Regenerating Public Residential Assets: Ex-Ante Evaluation Tools to Support Decision-Making

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Abstract

The increasing need to regenerate public housing stock highlights the importance of adopting integrated evaluation tools capable of supporting transparent, sustainable, and public value-oriented investment decisions. This study compares two alternative intervention strategies—renovation with extension and demolition followed by reconstruction—by applying a Cost–Benefit Analysis (CBA) model developed in two phases. In the first phase, the analysis focuses on social benefits, with the aim of assessing their contribution to collective well-being. The second phase incorporates potential energy-related benefits, estimated on the basis of performance improvements associated with the two design scenarios. The results demonstrate that the integrated consideration of economic, social, and energy–environmental dimensions affects the relative performance differences between the examined strategies, offering a more comprehensive evaluation framework than conventional approaches based solely on monetary costs. The proposed model, which is replicable in Mediterranean contexts, contributes to the ongoing international debate on ex ante evaluation tools and provides operational insights to support urban regeneration policies oriented towards more effective, equitable, and policy-consistent solutions, in line with the objectives of the European Green Deal and the 2030 Agenda. The two-phase structure allows decision-makers to distinguish between short-term social effects and long-term energy-related benefits, offering a transparent support tool for public investment choices under fiscal constraints.

Keywords: urban regeneration; public housing; building renovation; sustainability assessment; cost–benefit analysis; integrated decision-making

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1. Introduction

The European building sector is currently undergoing a structural transformation aimed at addressing the challenges associated with ecological transition, climate change, and social inclusion [1]. Buildings account for approximately 37% of global CO_2 emissions and about 40% of the total energy demand within the European Union, thus representing one of the main areas of intervention for achieving the decarbonization targets set by the European Green Deal and the Fit for 55 packages [2].

The existing building stock represents both a strategic resource and a structural challenge [3]. More than 75% of European residential buildings are energy-inefficient, with the highest incidence among buildings constructed between 1946 and 1980 [4]. Therefore, the challenge lies not only the improvement of energy performance, but also the broader

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regeneration of a building stock that is often outdated from technological, functional, and social perspectives [5].

In the Italian context, housing-related issues appear even more complex. Public policies implemented in the post-war period—from the INA-Casa Plan of 1949 to the Gescal of 1963, and later the 2008 Housing Plan—have resulted in an extensive stock of public housing, which is today frequently degraded and inadequate in terms of current standards of energy efficiency, accessibility, and urban quality [6,7]. Approximately 70% of Italian public housing buildings were constructed before 1980 and are characterized by high energy consumption, poor thermal performance, and significant maintenance deficiencies [8]. These conditions are further exacerbated by the increasing demand for social housing and the progressive reduction in public resources available for the management and renewal of the housing stock [9].

Urban regeneration and building refurbishment are recognized as priority strategies for promoting a sustainable, equitable, and resilient urban development model [10]. One of the most debated issues within the field of urban renewal is the choice between refurbishing existing buildings and demolishing them to construct new ones [11]. Refurbishment is often justified by principles of conserving the building stock, supporting the circular economy, reducing land consumption, and minimizing the environmental impact of construction materials [12]. In contrast, demolition and reconstruction offer the opportunity to introduce modern technological standards and new housing models, although they involve high initial costs and disrupt social continuity within communities [13].

While the topics of building retrofit and adaptive reuse have been widely explored in the literature, there is significant gap in comprehensive studies comparing the socio-economic impacts of alternative regeneration strategies in public housing contexts [14,15]. This gap is particularly significant in Southern European and Mediterranean areas, where public resource constraints and social vulnerability highlight the need for integrated evaluation frameworks to support design decisions [16].

This study aims to address this gap by comparing two intervention strategies applied to a public housing complex in Reggio Calabria, Italy. The first strategy involves the refurbishment and extension of the existing buildings, while the second involves demolition and reconstruction [17,18]. Both options are assessed through the application of a Cost–Benefit Analysis (CBA) model, which evaluates the economic efficiency, environmental sustainability, and social impacts of each approach [19]. The goal is to provide a robust, multi-dimensional evaluation framework that integrates economic, social, and environmental considerations to support public decision-making in urban regeneration and public housing management [20].

Although hybrid regeneration strategies combining refurbishment and selective demolition are frequently adopted in practice, this study deliberately focuses on two polar intervention logics. This choice is motivated by the need to preserve analytical clarity and to avoid overlapping cost–benefit flows that would hinder causal interpretation within an ex-ante evaluation framework.

2. Literature Review

Urban regeneration and the renewal of public residential assets constitute a central field of investigation within contemporary debates on sustainable development, climate change mitigation, and social equity [1]. At the global level, the building and construction sector is widely recognized as one of the most critical contributors to environmental pressures, accounting for a substantial share of energy consumption and greenhouse gas emissions [2]. According to recent international assessments, buildings are responsible for approximately 37% of global CO_2 emissions and represent a key leverage point for climate action [3]. Within the European Union, the relevance of the sector is even more pronounced, as buildings account for nearly 40% of final energy demand, thus positioning the built environment at the core of decarbonization and energy transition strategies [4].

In response to these challenges, international and European policy frameworks have increasingly emphasized the transformation of the existing building stock as a strategic priority [5]. Reports and policy documents produced by UN-Habitat and European housing institutions underline the structural weaknesses of current urban systems, highlighting the interconnections between housing quality, environmental performance, and social vulnerability [6]. Within this context, recent research has stressed the need to address the environmental and social implications of residential buildings through integrated renovation strategies, particularly in Southern European regions characterized by ageing housing stock and limited public resources [7]. These priorities are further reinforced by broader European policy agendas aimed at accelerating the ecological transition and strengthening social cohesion through targeted investments in the built environment [8].

A recurring issue in the literature concerns the age, condition, and energy performance of residential buildings [9]. A large proportion of European dwellings was constructed before the introduction of energy efficiency standards, especially during the post-war expansion between 1946 and 1980 [10]. As a result, more than 75% of residential buildings in Europe are currently classified as energy-inefficient, making renovation and retrofitting essential to achieve climate and energy targets [11]. Empirical evidence suggests that these challenges are particularly acute in Mediterranean countries, where climatic conditions, construction typologies, and socio-economic factors exacerbate energy poverty and environmental inefficiencies [12].

In Italy, the situation of public housing is emblematic of these broader dynamics [13]. National statistical sources highlight the advanced ageing and technical obsolescence of a large share of the public residential stock, often associated with inadequate maintenance and poor energy performance [14]. Historical analyses of housing policies further reveal how these structural deficiencies are intertwined with long-standing social and territorial inequalities, especially in peripheral and economically fragile urban areas. Consequently, the regeneration of public housing estates has emerged as a key policy objective, addressing not only environmental sustainability but also social inclusion and territorial cohesion [16].

Within this framework, energy retrofitting has been extensively examined as a primary strategy for improving the environmental performance of existing buildings [17]. The literature identifies a wide range of interventions, including thermal insulation of envelopes, replacement of windows and building systems, and integration of renewable energy technologies such as photovoltaic installations. These measures are widely recognized for their potential to reduce operational energy consumption and associated emissions [18,19]. At the same time, studies increasingly highlight the importance of considering embodied carbon and life-cycle impacts, particularly when comparing refurbishment and demolition scenarios [20].

Beyond environmental benefits, energy retrofitting is associated with significant economic and social co-benefits [21]. Several studies demonstrate that improved energy performance can reduce energy expenditures for households, lower operational costs for public authorities, and mitigate fuel poverty, thereby improving living conditions for vulnerable populations. In this sense, energy efficiency measures are increasingly framed as instruments of social policy, rather than purely technical solutions [22,23].

Parallel to energy-related considerations, the application of circular economy principles to the built environment has gained increasing attention [24]. The literature emphasizes practices such as reuse, repair, and recycling of materials as effective strategies for reducing construction and demolition waste and limiting the environmental footprint of urban development [25]. From this perspective, adaptive reuse of existing buildings is recognized as a key driver of sustainable development, as it preserves embodied energy, reduces land consumption, and supports local economic and social dynamics [26]. Systematic reviews confirm that adaptive reuse can significantly contribute to the achievement of Sustainable Development Goals, particularly in dense urban contexts where new land development is neither feasible nor desirable [27].

Urban regeneration strategies thus increasingly confront a fundamental decision-making dilemma: whether to refurbish existing buildings or to pursue demolition followed by reconstruction [28]. Refurbishment is often regarded as the more sustainable option, as it aligns with conservation principles, circular economy logic, and reduced resource consumption [29]. By retaining existing structures, refurbishment avoids the environmental and financial costs associated with new construction [30]. Conversely, demolition and reconstruction may enable the implementation of advanced technological standards and the resolution of functional obsolescence, accessibility deficits, and shortcomings in public space provision [31]. However, this approach typically entails higher initial costs, longer implementation periods, and potential disruption to established social networks [32].

A growing body of empirical research supports building retrofit and adaptive reuse as viable and sustainable alternatives to demolition, particularly when energy efficiency measures are integrated with broader social and environmental objectives [33]. Studies highlight how regeneration strategies that combine physical upgrading with social infrastructure, cultural enhancement, and participatory processes can generate substantial benefits in terms of resource conservation, social cohesion, and local economic vitality [34]. These outcomes are especially relevant in urban areas characterized by socio-economic fragility and limited public investment capacity [35].

In Mediterranean and Southern European contexts, decision-making in public housing regeneration is further complicated by financial constraints and the vulnerability of resident populations [36]. The literature increasingly underscores the need for integrated evaluation approaches capable of capturing not only economic efficiency but also social and environmental impacts that are difficult to monetize [37]. The provision of proximity services, shared spaces, green areas, and public amenities is consistently identified as a key factor in enhancing quality of life, promoting social inclusion, and reducing inequalities in regenerated neighborhoods [38].

Within this broad research landscape, a growing body of literature has focused on the development of ex-ante evaluation tools capable of supporting public decision-making in complex regeneration processes. These contributions emphasize the need for methodologies that go beyond purely financial metrics and are able to integrate environmental and social dimensions within a coherent analytical structure, particularly in the field of public housing and urban regeneration.

Against this backdrop, the evaluation of urban regeneration strategies has emerged as a crucial research domain [39]. Cost–Benefit Analysis is widely adopted to support public investment decisions and urban policy appraisal, offering a structured framework for comparing alternative interventions [40]. However, a substantial body of literature points to the limitations of conventional CBA in capturing non-market benefits, long-term environmental effects, and complex social outcomes [41]. Recent contributions therefore call for more comprehensive and integrated evaluation models capable of incorporating energy-related benefits, social externalities, and policy objectives within ex-ante decision-making processes [41].

Overall, the literature converges on the recognition that the regeneration of public housing requires multidimensional and integrated approaches that combine environmental sustainability, social equity, and economic feasibility [39,40]. Building on this body of research, the present study contributes to the ongoing debate by proposing a comparative assessment of refurbishment and demolition/reconstruction strategies for a public housing complex in Southern Italy, using an integrated Cost–Benefit Analysis framework to support informed, equitable, and sustainability-oriented decision-making [41].

Compared to alternative evaluation approaches, the Cost–Benefit Analysis was selected as the backbone framework of this study due to its widespread use in public investment appraisal and its ability to ensure comparability and transparency in decision-making. At the same time, the proposed model acknowledges the limitations of conventional CBA by explicitly structuring social and energy-related benefits into two separate analytical phases, thus enhancing interpretability and policy relevance [41–44]. The framework is therefore conceived as complementary to, rather than in competition with, multi-criteria or social evaluation approaches.

As shown in Table 1 (Comparative overview of evaluation approaches adopted in urban regeneration and public housing assessment), Cost–Benefit Analysis emerges as the reference framework for ex-ante public investment appraisal, consistently with the European Commission guidelines for cohesion policy and major public projects [45]. These guidelines provide a common methodological language grounded in transparency, comparability, and conservative assumptions in the monetization of social and environmental impacts. Within this institutional context, the present study adopts CBA as its analytical backbone and advances it by introducing a two-phase structure that enhances the readability and interpretability of social and energy-related effects without departing from established European evaluation standards.

Table 1. Comparative overview of evaluation approaches adopted in urban regeneration and public housing assessment. (EU CBA Guidelines integrated across approaches) [45].

Evaluation Approach	**Main Objective**	**Outputs**	**Treatment of Social Impacts**	**Treatment of Environmental/Energy Impacts**	**Strengths**	**Main Limitations**	**Suitability for Ex-Ante Public Decision-Making**
Cost–Benefit Analysis (CBA)	Assess the economic feasibility of interventions by comparing monetised costs and benefits over time	NPV, BCR, IRR	Monetised through shadow prices and conservative proxies, in line with EU appraisal practices	Explicit monetization of energy savings and emissions when reliable coefficients are available	High transparency and comparability; alignment with EU public investment appraisal standards	Limited ability to capture intangible and cultural values	High
Multi-Criteria Analysis (MCA)	Compare alternatives across multiple qualitative and quantitative criteria	Rankings and weighted scores	Explicit inclusion of social and distributive effects through qualitative indicators	Considered through non-monetary environmental criteria	Ability to capture complex and intangible dimensions	Subjectivity in weighting; limited comparability and budgetary operability	Medium (complementary)
Social Return on Investment (SROI)	Measure the social value generated by interventions in monetary terms	Social value ratios	Central focus, often based on stakeholder engagement	Included when directly linked to social outcomes	Strong social orientation and stakeholder involvement	High data requirements; limited standardization	Medium–low

Table 1. *Cont.*

Evaluation Approach	Main Objective	Outputs	Treatment of Social Impacts	Treatment of Environmental/Energy Impacts	Strengths	Main Limitations	Suitability for Ex-Ante Public Decision-Making
Life Cycle Assessment (LCA)	Quantify environmental impacts over the life cycle of interventions	Environmental impact indicators (e.g., CO_2, energy use)	Generally excluded	Core analytical focus; high methodological rigour	Robust environmental assessment	Limited integration with economic and social evaluation	Medium (complementary)
Cost-Effectiveness Analysis (CEA)	Identify the least-cost option to achieve predefined policy targets	Cost per unit of outcome	Implicit, target-oriented	Considered in relation to specific performance goals	Simplicity and clarity	Inability to compare heterogeneous benefits	Medium

3. Methodology and Analysis

The analysis presented in this study adopts a Cost–Benefit Analysis (CBA) framework to evaluate and compare the economic and social desirability of two alternative urban regeneration strategies applied to a public housing complex located in Reggio Calabria, Italy: Scenario 1 (Renovation with Expansion) and Scenario 2 (Demolition and Reconstruction). The primary objective is to assess the overall social desirability of each intervention by systematically identifying, quantifying, and comparing the associated costs and benefits over the project lifecycle, in line with established principles of public project appraisal and regulatory policy evaluation [7,39].

3.1. Case Study

The analyzed case study concerns a public housing complex located in the southern outskirts of Reggio Calabria (Italy) (Figure 1).

Figure 1. Study Area of Viale Europa (Reggio Calabria, Italy) (Lat: 38.0956; Lon: 15.6483). In the large image on the right, the shaded area highlights the public housing complex under study.

To improve clarity and facilitate the replicability of the proposed evaluation framework, the main technical, social, and contextual characteristics of the case study are summarized in Table 2. This structured overview supports a clearer understanding of the representativeness of the selected public housing complex within Mediterranean and Southern European contexts.

Table 2. Main characteristics of the case study.

Parameter	Description
Location	Public housing complex located in Reggio Calabria, Southern Italy, within a consolidated urban area characterized by proximity to basic services and transport infrastructure.
Period of construction	Built between the late 1960s and early 1970s, during the post-war expansion phase of public housing development in Italy.
Number of dwellings	A total of 384 residential units distributed across multi-storey buildings.
Population	Approximately 884 residents, predominantly composed of low-income households and elderly inhabitants.
Main criticalities	Obsolete building envelope and systems, high energy consumption, limited accessibility, inadequate outdoor and communal spaces, and physical degradation of structures.
Socio-economic context	The surrounding urban context is characterized by low average income levels, a high incidence of social vulnerability and energy poverty, and limited access to private investment, reflecting conditions commonly observed in Mediterranean and Southern European cities.

The intervention takes place in a context characterized by socioeconomic fragility and building degradation, which is representative of many urban areas in southern Italy.

Reggio Calabria has an average disposable income 35% lower than the national average, an unemployment rate exceeding 20%, and one of the highest energy poverty indices in Italy. These data reflect the structural and social vulnerability of the area, where public housing plays a key role in ensuring the right to housing and territorial cohesion [3,30].

The area represents an emblematic context of the dynamics of public residential housing in the city, where the need to ensure affordable housing has historically faced challenges such as fragmented management and insufficient maintenance.

The user base of the housing complex, consisting of 384 units, was estimated to be around 884 people, based on ISTAT 2022 [8] data indicating an average of 2.3 inhabitants per household.

The complex, built between the 1960s and 1970s, consists of 3–5 story buildings made with reinforced concrete supporting structures, brick infill walls, and flat roofs. The apartments, ranging from 50 to 85 m^2, are organized in two-bedroom, three-bedroom, and four-bedroom units.

The balcony-style distribution is a distinctive yet critical typological element, as it reduces privacy and compromises living comfort: access to individual units is through common spaces that are exposed and passable by all residents.

The widespread building degradation is a direct result of the lack of maintenance and absence of a continuous management plan.

The main issues identified include

- Degradation of materials and widespread infiltration;
- Absence of thermal insulation and inefficient systems;
- Poor accessibility (lack of elevators and architectural barriers);
- Inadequacy of public spaces and lack of equipped green areas;
- High thermal dispersion and low levels of living comfort.

Thus, the complex represents a typical example of post-war public housing, where physical deterioration accompanies progressive social marginalization.

The research conducted at the LandEM Lab "Edoardo Mollica" of the Mediterranean University of Reggio Calabria focused on a prototype building within the complex, to analyze the critical issues and propose two design alternatives, corresponding to different regeneration strategies:

Scenario 1—Renovation with expansion of the existing structure: This scenario involves the recovery of the existing buildings through energy efficiency improvements, seismic upgrades, and typological reorganization of the apartments. It includes the addition of a floor to three of the building blocks, increasing the volume by 15%, dedicated to new residential units and communal spaces.

Scenario 2—Demolition and reconstruction: This scenario proposes the complete demolition of the complex and the construction of new buildings to Nearly Zero Energy Building (NZEB) standards, with the same number of apartments and new, high-efficiency systems.

Both scenarios were developed based on technical surveys and updated economic estimates, to ensure data comparability within the Cost–Benefit Analysis (CBA) model.

Intervention Scenarios

Scenario 1: Renovation and Expansion. The intervention was tested on a prototype building, selected as a representative sample of the entire complex, to identify replicable and scalable solutions applicable to all buildings within the intervention area.

The overall objective of the project is to improve living comfort, energy efficiency, and urban livability, while simultaneously enhancing the common open spaces and the connection with the central park. The project aims to create a sustainable and integrated living environment that strengthens the quality of life and social inclusion.

At the urban scale, the intervention envisages an overall reorganization of external spaces, including

- New dedicated and safe pedestrian and cycle–pedestrian paths;
- Relocation of parking areas along the main road system, freeing the space in front of the buildings for community-oriented functions;
- Tree-lined alignments and green buffers to mitigate noise and visual impact;
- Multifunctional spaces and sports and cultural facilities to promote social interaction and public use.

At the building scale, the intervention includes an internal reorganization of the residential units and the provision of shared services at ground level.

The main actions include

- Installation of external thermal insulation on all façades, with demolition of the existing infill walls and construction of new openable glazed loggias, conceived as bioclimatic buffer zones aimed at improving daylighting and thermal comfort;
- Redesign of the loggias on both fronts to ensure adequate natural light and enhanced architectural quality;
- Retention of the original locations of sanitary cores, in order to reduce intervention complexity and costs;
- Redesign of internal partitions to improve functional layout and privacy;
- Extension of stairwells and elevator shafts to connect the new rooftop extension level, equipped with large vertical glazed surfaces to enhance visual connections with the exterior and a perception of openness.

The building, articulated into three identical blocks, each served by two stairwells and an elevator, originally accommodates six apartments per block (two-room, three-room, and four-room units). The project preserves the original modular structure, while introducing new housing types with integrated loggias:

- Three-room apartment: 73 m^2 + loggia;
- Two-room apartment: 54 m^2 + loggia;
- Four-room apartment: 83 m^2 + loggia (two variants).

In addition to the refurbishment of the existing structure, a rooftop extension is planned, consisting of independent volumes intended, after completion, to host community services. The new units in the extension are designed with flexible and adaptable solutions, allowing easy conversion from temporary housing to collective uses (e.g., coworking spaces, laboratories, or neighborhood services).

The new typologies in the rooftop extension include

- Four-room apartment: 123 m^2;
- Three-room apartment: 83 m^2;
- Two-room apartment: 53 m^2.

The intervention has been planned in sequential phases, to ensure housing continuity and an efficient management of resources. The modularity and replicability of the project allow the model to be extended to the entire complex, ensuring architectural coherence, operational flexibility, and economic sustainability.

Scenario 2: Demolition and Reconstruction. The second design strategy, developed at both the urban and building scales within the teaching activities of the Economic Evaluation course at the Faculty of Architecture at the Mediterranean University of Reggio Calabria, differs from the first option in terms of the scale of intervention, which extendes to the entire ERP complex along Viale Europa, as well as the comprehensive design of neighborhood services and infrastructures.

The intervention involves the demolition of the existing buildings and the construction of a new residential complex characterized by high standards of environmental sustainability, architectural quality, and urban integration.

The overall objective is to redefine the settlement layout, improving energy and acoustic performance, safety, ecological continuity, and the connection with the existing urban green system along Viale Europa.

At the urban scale, the project proposes

- An integrated reorganization of open spaces, with continuous pedestrian and cycle paths;
- The creation of a green corridor along the avenue, acting as a natural barrier against noise and air pollution;
- New tree planting and equipped green areas to encourage collective use;
- The construction of underground parking facilities, connected by ramps and elevators, in order to free surface areas for public and recreational functions;
- Spaces for sports and cultural activities distributed across open areas, aimed at strengthening neighborhood social cohesion.

At the building scale, the new configuration replaces the linear balcony-access typology of the original complex, replacing it with seven compact blocks of varying heights, oriented to maximize solar exposure and natural ventilation.

The ground floors accommodate collective services and meeting spaces, while the upper floors are dedicated to housing units of different sizes:

- Two-room apartments: 50–60 m^2;
- Three-room apartments: 80–90 m^2;
- Four-room apartments: 100–120 m^2.

The buildings are organized into two separate cores connected by open galleries and stairwells, ensuring greater visual permeability, cross-ventilation, and the presence of directly accessible green spaces.

The architectural approach of the new blocks aims to overcome the rigidity of the existing structures, proposing a dynamic and modular morphology capable of adapting to diverse housing needs.

The construction process is planned in two operational phases, to avoid the simultaneous relocation of all residents.

Demolition and reconstruction activities are carried out in sequence:

1. In the first phase, underground parking facilities and the first two buildings are constructed and temporarily allocated to accommodate residents from the subsequent blocks;
2. Once the relocation process is completed, the demolition and reconstruction of the remaining buildings take place.

The entire cycle is planned within a schedule of approximately 4–5 years, allowing for the progressive rotation of tenants and a reduction in the costs associated with temporary relocation.

In summary, this second option can be interpreted as a comprehensive regeneration of the ERP neighborhood along Viale Europa, aimed at the creation of a new sustainable housing model based on

- Energy efficiency and integrated resource management;
- Architectural and spatial quality;
- Enhancement of collective service provision;
- Social inclusion and well-being of the resident community.

The case study represents an operational application of the CBA model proposed in next section, allowing the tool's capacity to be tested in terms of its ability to represent, in an integrated manner, the economic and social impacts of urban regeneration choices.

The results obtained—presented in Section 6—enable a comparison between the two strategies in terms of financial efficiency, environmental sustainability, and generated social value, providing empirical evidence that is useful for the planning of similar interventions in Mediterranean ERP contexts.

Due to its representativeness and complexity, the Reggio Calabria case also offers a replicable methodological basis for the evaluation of ERP projects in resource-constrained settings, contributing to the European debate on the sustainable regeneration of public housing [16,27].

3.2. Approach and Framework

This research follows the guidelines of the Guide to Cost–Benefit Analysis of Investment Projects provided by the European Commission, ensuring that the methodology used is transparent, reproducible, and comparable across different urban contexts [21]. The methodology is organized into a sequence of structured phases to ensure thorough evaluation and the robustness of results.

The CBA method is based on the principle of allocative efficiency, meaning an intervention is deemed socially justified if the total benefits to the community exceed the total costs incurred [39–44]. In the field of building and urban regeneration, CBA has been progressively adopted for the evaluation of energy retrofitting interventions, the regeneration of public housing stock, and sustainable housing policies, even in contexts characterized by socio-economic vulnerability [45–47].

3.3. Two-Phase Approach

The study employs a two-phase CBA approach, with each phase designed to reflect specific elements of the regeneration interventions:

1. Phase 1: Social Benefits and Proximity Services

This phase focuses exclusively on the monetization of social benefits associated with the two scenarios. These benefits include housing continuity, local services, health improvements, reduced travel, and urban quality enhancements. Economic benefits and energy savings are deliberately excluded in this phase to isolate the net social contribution of the two strategies.

The social benefits are monetized using data from community surveys and qualitative assessments of proximity services that can improve the quality of life in the housing complex. These services are critical in addressing urban vulnerability and improving residents' well-being [7,48].

2. Phase 2: Integration of Energy Benefits and Economic Savings

In this phase, a simplified energy assessment is added, based on reference consumption and the estimation of energy savings for both scenarios. These include reduced energy use, improvements in energy efficiency, and photovoltaic production. Scenario 1 focuses on energy retrofitting, while Scenario 2 involves the construction of a new, energy-efficient building designed to meet Nearly Zero Energy Building (NZEB) standards [49–51].

The inclusion of energy benefits allows for the evaluation of economic savings generated by energy efficiency improvements, providing a more comprehensive analysis of the total social value of the interventions [41,52–54].

This two-phase structure highlights how the introduction of energy benefits modifies the overall economic convenience of the projects and enables clearer interpretative analysis, especially for policymakers aiming to evaluate the incremental social value of these strategies [7].

It should be noted that not all social impacts associated with the regeneration strategies were monetised. Only those benefits for which conservative, literature-backed proxies were available were included in the quantitative analysis. Intangible dimensions—such as cultural attachment, social identity, and symbolic values—were intentionally excluded from monetization and are discussed qualitatively, in order to avoid speculative estimations and to preserve the robustness of the cost–benefit analysis.

3.4. Cost–Benefit Analysis Model

The CBA model used in this study evaluates the economic and social impacts of each scenario by calculating Net Present Value (NPV), benefit–cost ratio (BCR), and Internal Rate of Return (IRR) for each strategy. The results of the analysis will be used to determine the overall social desirability of each intervention.

Phase 1 focuses solely on social benefits and proximity services, while Phase 2 integrates the additional benefits from energy efficiency and economic savings.

The assessment is performed over a 30-year time horizon, and all costs and benefits are expressed in current euros and subsequently discounted to 2025 values.

3.5. Data Collection and Sources

Data used for the analysis were obtained from various reliable sources:

1. Technical and Diagnostic Surveys: Surveys conducted in 2023 provided detailed data on the physical condition of the public housing complex, including energy performance, structural integrity, and maintenance needs;
2. Regional and National Price Lists: The DEI Price List (2024) and Reggio Calabria regional construction cost lists were used for estimating construction and maintenance costs [55];
3. Energy Consumption: Energy consumption values were estimated according to the UNI/TS 11300 and EPBD 2023 standards [49,50];
4. Environmental and Social Costs: The social cost of carbon and CO_2 emissions values were based on European reference values, with the social cost of carbon set at 80 EUR/ton CO_2 [52].

All costs and benefits were expressed in current euros and subsequently discounted to 2025 values.

Table 3 provides a structured overview of the social sustainability indicators included in the analysis, together with their data sources, reference literature, and rationale for monetization. The selection of indicators was guided by the availability of conservative and literature-backed proxies, in line with the ex-ante nature of the evaluation and with European public investment appraisal practices. Indicators for which reliable monetization was not feasible were intentionally excluded and are discussed qualitatively in the Section 5.

Table 3. Social sustainability indicators adopted in the cost–benefit analysis.

Social Indicator	Description	Data Source	Reference Literature	Rationale for Inclusion
Reduction in energy poverty	Decrease in household energy expenditure resulting from improved energy efficiency	National statistics (ISTAT) [8]; energy performance data; case study surveys	European Commission Renovation Wave [2]; EU CBA Guidelines [21,45]; energy efficiency and housing affordability studies [5,13,47]	Directly linked to household welfare and measurable through energy cost savings
Improvement of indoor comfort	Enhanced thermal and living comfort conditions within dwellings	Building performance assessments; technical standards (UNI/TS 11300)	Building physics and housing quality studies [14,34,49]	Affects health, well-being, and habitability of social housing
Accessibility to proximity services	Improved access to essential services and communal facilities	GIS analysis; municipal spatial data	Urban accessibility and social inclusion literature [12,35,38]	Supports social inclusion and daily life quality
Reduction in social vulnerability	Decrease in exposure to socio-economic risk factors	Census data; local socio-economic indicators	Social housing, vulnerability and inclusive housing policies literature [9,13,23]	Reflects broader social benefits of regeneration in disadvantaged urban contexts
Enhanced safety and usability of shared spaces	Improvement in perceived and actual safety of outdoor and communal areas	Project documentation; qualitative assessments	Urban regeneration, public space and social cohesion literature [16,35,38,54]	Contributes to social cohesion, liveability, and neighbourhood stability

3.6. Economic Indicators

To evaluate the economic and social sustainability of the two scenarios, the following economic indicators were used:

(a) Net Present Value (NPV), Formula (1):

$$NPV = \sum_{t=0}^{T} \frac{F_t}{(1+r)^t}, \tag{1}$$

where

- Ft = Bt − Ct represents the net benefit flow at time t, defined as the difference between revenues (Rt) and costs (Ct);
- Bt are the monetized benefits at time t;
- Ct are the total costs at time t, including investment and management costs;
- r is the social discount rate (3%), equivalent to the opportunity cost of capital;
- T is the reference time horizon (30 years), representing the duration of the investment (from 0 to T).

NPV represents the total net benefit generated by the project for the community. In the public sector, a positive NPV indicates that the benefits exceed the costs, justifying the intervention in terms of allocative efficiency [39,45–47].

(b) Benefit–cost ratio (BCR), Formula (2):

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}. \tag{2}$$

This indicator expresses the ratio between the discounted value of social benefits and the discounted value of total costs.

A benefit–cost ratio (BCR) greater than 1 indicates the socio-economic convenience of the project, while values below 1 suggest a lack of economic sustainability in the long term [21,22,39].

(c) Internal Rate of Return (IRR), Formula (3):

$$NPV = \sum_{t=0}^{T} \frac{F_t}{(1+T)^t} = 0. \tag{3}$$

The IRR represents the discount rate that makes the NPV of the project equal to zero. In public projects, the acceptability condition is given by

$$IRR > r,$$

where r is the social discount rate.

Thus, the IRR is the discount rate r that makes the Net Present Value (NPV) equal to zero. It represents the overall profitability of the intervention.

If IRR > r (social discount rate), the investment is considered acceptable.

In public economics literature, IRR is often used in combination with NPV to compare alternative projects of different scale and duration [44,47–54].

(d) Payback Period (PBP), Formula (4).

The PBP represents the time required to recover the initial investment. Although it does not account for the time value of money, it provides a concise indicator of the speed of capital recovery.

The discounted benefit–cost ratio (BCR) is a key indicator for evaluating the long-term convenience of a project or investment. It is calculated as the ratio between the discounted value of benefits and the discounted value of costs over the entire life cycle of the project or investment (Formula (4)):

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}. \tag{4}$$

For a project to be considered economically convenient, the discounted benefit–cost ratio (BCR) must be greater than 1. This means that the expected benefits exceed the projected costs, taking their present value into account. The higher the ratio, the more the project is considered advantageous, as it indicates that benefits outweigh costs to a greater extent.

The Payback Period (PBP) is used to assess the profitability of an investment or project. It indicates the time required for the cash flows generated by an investment to fully recover the initial cost of the investment. It represents the number of time periods (usually expressed in years) needed to achieve a return on investment equal to the initial investment cost [39].

The integration of these summary indicators allows for a more robust evaluation of the economic and social sustainability of the two alternatives [21,22].

3.7. Sensitivity Analysis

To ensure the robustness of the results and assess the economic resilience of the proposed strategies, a sensitivity analysis was conducted. The following variables were varied to test the stability of the results:

- Discount rate (±1%);
- Cost of materials and energy (±10%);
- Variation in estimated social benefits (±15%).

This analysis ensures that the model can withstand macroeconomic and environmental uncertainties, providing a clearer understanding of the potential risks and benefits of each intervention under varying conditions [21,22,41].

4. Results

The application of the Cost–Benefit Analysis (CBA) model to the two intervention scenarios developed for the Viale Europa ERP complex allowed for a systematic evaluation of the impacts of the two urban regeneration alternatives.

The CBA model was applied in two phases: in Phase 1, the assessment considered only social benefits, deliberately excluding economic–financial benefits and energy savings; subsequently, in Phase 2, the monetization of energy benefits was integrated. The analysis was carried out over a 30-year time horizon, with a 3% discount rate, in accordance with the methodological framework described in Section 5 [20,21].

4.1. Phase 1 Results—Technical and Economic Parameterization of Scenarios

To ensure transparency and reproducibility, the main parameters adopted for each scenario are reported below (Table 1).

Scenario 1: Renovation and Expansion

- Total initial investment: EUR 24,820,000;
- Gross Floor Area (GFA), sum of relevant areas (residential + tertiary + underground parking, where present): 31,238 m^2 (Residential + Tertiary);
- Planned volumetric increase: +15% on three building blocks (rooftop extension);

- Type of interventions: external thermal insulation, window replacement, system upgrades, seismic improvement, provision of proximity services (laundry, common spaces);
- Estimated operational costs (post-intervention): average annual reduction of 25% compared to current levels.

Scenario 2: Demolition and Reconstruction

- Total initial investment: EUR 120,594,000;
- Planned GFA: 59,226 m^2 (higher total volume) (Residential + Tertiary + Underground Parking);
- Type of interventions: complete demolition, NZEB reconstruction, underground parking, new urban layout;
- Estimated operational costs (post-intervention): greater reduction in energy consumption but with significantly higher capital costs;

Costs were estimated using official price lists [55] and, where unavailable, based on recent constructions in similar or neighboring contexts [56–58].

The main dimensional and economic parameters of the two scenarios are summarized in Table 4.

Table 4. Technical–Economic Parameterization of the Interventions.

Scenario 1 Renovation and Expansion		**Scenario 2 Demolition and Reconstruction**	
Intervention Dimensions		**Intervention Dimensions**	
Apartments (n.)	384	Apartments (n.)	384
		Demolition (EUR /m$^{3\,1}$)	121,718
Residential (m^2 GFA)	28,700	Residential (m^2 GFA)	51,634
Tertiary (m^2 GFA)	2600	Tertiary (m^2 GFA)	3592
Underground Parking (GFA)	0	Underground Parking (m^2 GFA)	4000
Standard Areas		**Standard Areas**	
Public green space (m^2)	27,900	Public green space (m^2)	36,910
Surface parking (m^2)	9000	Surface parking (m^2)	2000
Residual Value		**Residual Value**	
Investment duration (years)	30	Investment duration (years)	30
Economic life (years)	50 anni	Economic life (years)	50
Construction cost (EUR)	24,855,506.00	Construction cost (EUR)	561,178,981.36
Average agricultural value (EUR/h)	27,656.00	Average agricultural value (EUR/h)	27,656.00
Residual value (EUR)	10,070,000.00	Residual value (EUR)	48,379,600.00
Costs Urbanization:		**Costs**	
Public green space (EUR/m$^{2\,1}$)	60	Demolition (EUR/m$^{3\,1}$)	16
		Temporary relocation of residents (EUR/apartment ^{3})	2518.00
Public parking (EUR/m$^{2\,1}$)	80		
Residential IP 1 (EUR/m$^{2\,1,4}$)	717.62	**Costs Urbanization:**	
Tertiary IP 1 (EUR/m$^{2\,1,4}$)	717.62	Public green space (EUR/m$^{2\,1}$)	60
Underground parking (EUR/m$^{2\,4}$ per parking space ^{1})	13,000	Public parking (EUR/m$^{2\,1}$)	80
		Residential IP 1 (EUR/m$^{2\,1,4}$)	2109.58
		Tertiary IP 1 (EUR/m$^{2\,1\,4}$)	2109.58
		Underground parking (EUR/m$^{2\,4}$ per parking space ^{1})	13,000
Building costs		**Building costs**	
Residential (EUR/m$^{2\,2}$)	717.62	Residential (EUR/m$^{2\,2}$)	2109.58
Tertiary (EUR/m$^{2\,2}$)	717.62	Tertiary (EUR/m$^{2\,2}$)	2109.58
Underground parking (EUR/parking ^{1})	13,000	Underground parking (EUR/parking ^{1})	13,000

Sources: [1] Prezzario DEI [55]; [2] Case Study; [3] EUR/apartment—Real Estate Market Observatory (OMI) [59]; [4] Gross Floor Area (GFA).

4.2. Phase 1 Results—Monetization of Social Benefits and Proximity Services

Social and proximity-related benefits are not symmetric between the two scenarios, as they derive from social, functional, and settlement conditions that are deeply different. Scenario 1 generates effective incremental benefits with respect to the existing situation, whereas Scenario 2 does not allow for direct monetization, since it involves the complete demolition of the existing buildings and the temporary relocation of residents.

In Scenario 1, in addition to energy-related benefits, the rehabilitation intervention produces indirect environmental benefits linked to reduced land consumption, lower amounts of demolition waste, and the reuse of existing structures. Moreover, the assessment integrates the evaluation of the proximity services included in the proposal, with particular attention to their economic and social effects on resident users [60].

In Scenario 2, these benefits are not applicable, as the living conditions of the neighborhood change radically, and no measurable incremental benefit is generated in the short to medium term.

The adopted methodology quantifies direct and indirect savings resulting from the activation of shared condominium services, considering three main components (Table 5):

- Direct economic savings (collective use of facilities leading to economies of scale);
- Savings from avoided travel (lower fuel consumption and reduced time losses);
- Environmental benefits (reduced emissions and lower energy consumption) [7].

Table 5. Benefits estimate.

Benefits	Description		N. Users	Formula
Travel	Fuel savings	Car owners	478	R = (LC × CC) × U
Housing rent	Office rent savings	Workers and professionals	151	R = (CAP × CAC) × U
Cultural exchange	Increase in social capital	Workers	546	Not monetizable
Health	Reduction in healthcare expenditures	Active population	609	R = (SF × CS/PF) × U
Cultural activities	Skills enhancement	Entire population	437	Not monetizable
Safety	Reduction in theft risk	Car owners	384	Not monetizable
Vehicle maintenance	Reduction in vehicle wear and tear	Car owners	384	Not monetizable

Specifically, the terms in Table 5 explain that:

- R = Total annual economic savings generated by the benefit;
- U = Number of users benefiting from the service;
- LC = Liters of fuel consumed per trip;
- CC = Fuel cost (EUR/liter);
- CAP = Annual cost of renting a private office;
- CAC = Annual cost of renting a coworking/shared space;
- SF = Annual healthcare expenses per family;
- CS = Economic cost attributable to sedentary behavior (prevention cost/lack of physical activity) PF = Average number of persons per family.

The formule R = (LC × CC) × U; R = (CAP × CAC) × U and R = (SF × CS/PF) × U represent the way in which the total savings generated by each benefit are calculated, by multiplying a unit savings value by the number of users involved.

By way of example, the shared condominium laundry service represents a paradigmatic case of the micro-monetization of proximity-based services.

Component 1—Savings related to travel reduction:

$$\text{Sspost} = [(1.6\ \text{km/trip} \times 12\ \text{trips/year})/14.5\ \text{km/L}] \times 1.7515\ \text{EUR/L} = \text{EUR}\ 4.64/\text{person/year}$$

Component 2—Reduction in external laundry costs:

Based on local tariffs and average consumption levels, a significant reduction in annual costs was estimated.

The Equation (5) compares the cost of the service in the absence of the project with the cost under the project scenario, net of the savings associated avoided travel.

Final formula for percentage reduction:

$$\text{Reduction (\%)} = [(\text{Cext} - (\text{Ccond} - \text{Sspost})/\text{Cext}] \times 100 \quad (5)$$

dove:

Reduction (%) = Percentage of savings achieved with respect to the cost of external laundry services;

Cext = Annual cost of external laundry (traditional commercial service);

Ccond = Annual cost of the shared condominium laundry service:

Sspost = Annual savings from avoided travel (fuel, time, vehicle wear).

The difference between the two values, expressed relative to C_ext, indicates the percentage of savings generated by the shared service.

By applying Equation (5), an average reduction of 36% per household is obtained.

The monetization of social benefits was conducted using conservative and literature-backed proxy values, consistently with the ex-ante nature of the assessment and with European public investment appraisal guidelines [21,45,61–74]. For proximity services and collective facilities, social benefits were estimated through avoided travel costs, calculated by multiplying average per capita travel expenses by the expected number of users and annual frequency of use, derived from local surveys and comparable case studies [38,59]. Health-related benefits were monetized using standard per capita values associated with improved housing conditions and reduced exposure to energy poverty, as reported in public health and housing literature [47,71]. These assumptions prioritize transparency and replicability over completeness, acknowledging that several social effects—such as social cohesion and informal support networks—cannot be fully captured through monetary indicators and are therefore discussed qualitatively [41,74].

Once the monetization process for each benefit was completed and an estimate of the financial savings generated by their presence was obtained, this value was integrated into the initial dataset together with the costs previously defined.

These data form the basis for the generation of cash flows and for carrying out the cost–benefit analysis.

In Table 6, the summary tables of the initial data for both project scenarios are presented.

Table 6. Database for Cash Flow Analysis.

Scenario 1 Renovation and Expansion		**Scenario 2 Demolition and Reconstruction**	
Intervention Dimensions		**Intervention Dimensions**	
Apartments (n.)	384	Apartments (n.)	384
		Demolition (EUR/$m^{3\,1}$)	121,718
Residential (m^2 GFA ^{3})	28,700	Residential (m^2 GFA)	51,634
Tertiary (m^2 GFA)	2600	Tertiary (m^2 GFA)	3592
Underground Parking GFA (m^2 GFA)	0	Underground Parking GFA (m^2 GFA)	4000
Standard Areas		**Standard Areas**	
Public green space (m^2)	27,900	Public green space (m^2)	36,910
Surface parking (m^2)	9000	Surface parking (m^2)	2000

Table 6. *Cont.*

Scenario 1 Renovation and Expansion		Scenario 2 Demolition and Reconstruction	
Residual Value		**Residual Value**	
Investment duration (years)	30	Investment duration (years)	30
Economic life (years)	50 anni	Economic life (years)	50
Construction cost (EUR)	24,855,506.00	Construction cost (EUR)	561,178,981.36
Average agricultural value (EUR/h)	27,656.00	Average agricultural value (EUR/h)	27,656.00
Residual value (EUR)	10,070,000.00	Residual value (EUR)	48,379,637.00
Costs Urbanization		**Costs**	
Public green space (EUR/m^{2} [1])	60	Demolition (EUR/m^{3} [1])	16
Public parking (EUR/m^{2} [1])	80	Temporary relocation of residents (EUR/apartment [2])	2518.32
Residential IP 1 (EUR/m^{2} [1,3])	717.62	**Costs Urbanization:**	
Tertiary IP 1 (EUR/m^{2} [1,3])	717.62	Public green space (EUR/m^{2} [1])	60
Benefits [3]		**Benefits** [3]	
Travel costs for cinema activities (EUR/person)	26.50	Travel costs for cinema activities (EUR/person)	26.50
Travel costs for theatre activities (EUR/person	25.00	Travel costs for theatre activities (EUR/person	25.00
Travel costs for gym/fitness activities (EUR/person)	30.00	Travel costs for gym/fitness activities (EUR/person)	30.00
Travel costs for work commuting (EUR/person)	2139.00	Travel costs for work commuting (EUR/person)	2139.00
Travel costs for daycare/playroom activities (EUR/person)	32.50	Travel costs for daycare/playroom activities (EUR/person)	32.50
Health benefits (EUR/person)	272.00	Coworking-related travel costs (EUR/person)	910.00
		Health benefits (EUR/person)	272.00

Sources: [1] Prezzario DEI [55]; [2] EUR/apartment—Real Estate Market Observatory (OMI) [59]; [3] Gross Floor Area.

4.3. Phase 1 Results—Discounted Cash Flows and Indicators

Proceeding with the comparison between the costs and benefits associated with the two project scenarios, the first step consists of defining the discount rate, which was set at 3%.

The time horizon adopted for the analysis is equally crucial for the calculation. As previously anticipated, a 30-year period was selected in the study, starting from the tenth year at full operation, to analyze the cash flows.

Cash flows were calculated for both scenarios and subsequently compared.

In the Appendix A, a reduced version of the Cost–Benefit Analysis (CBA) is reported, together with the related results for both scenarios in Phase 1.

In Scenario 1 (Refurbishment with Extension), a three-year construction period was assumed, after which the services within the area begin to generate benefits. It is expected that by the tenth year the user base benefiting from these services will reach its maximum capacity.

In Scenario 2 (Demolition and Reconstruction), works were planned according to the construction schedule, with longer implementation times due to the demolition activities required.

For Scenario 1 (Refurbishment with Extension),the Net Present Value (NPV) is negative, while for Scenario 2 (Demolition and Reconstruction), the NPV takes on an even more negative value, due to the higher investment costs required for demolition and new construction.

Given the presence of negative NPVs for both options, the Internal Rate of Return (IRR) was not calculated, as it would have produced non-meaningful values.

The same applies to the discounted benefit–cost ratio (BCR), which is below unity in both scenarios.

The Payback Period (PBP) indicates a particularly long capital recovery time: approximately 45 years for Scenario 1 and more than 60 years for Scenario 2.

These results do not indicate an absolute lack of convenience, but rather reflect the methodological setting of Phase 1, which aims to isolate social benefits only.

Table 7 reports the results for the two scenarios. To facilitate the interpretation of the transition between Phase 1 and Phase 2 results, Sankey diagram (Figure 2) provides a visual synthesis of the main cost–benefit flows associated with the two scenarios, illustrating the main cost–benefit flows for Scenario 1 (refurbishment) and Scenario 2 (demolition and reconstruction) across Phase 1 and Phase 2 of the assessment. The visualization highlights how the integration of energy-related benefits in Phase 2 alters the overall balance, leading to a positive net result for Scenario 1, while Scenario 2 remains economically unfeasible.

Table 7. Results for the two scenarios.

Indicators	Scenario 1	Scenario 2
Total investment (EUR)	24,855,506.00	561,178,981.00
Net present value (NPV) (EUR)	−5,100,923	−75,303,975
Benefit–cost ratio (B/C)	0.78	0.32
Payback period (PBP, years)	45	>60
Residual value (EUR)—30th year	10,070,000.00	48,379,600.00

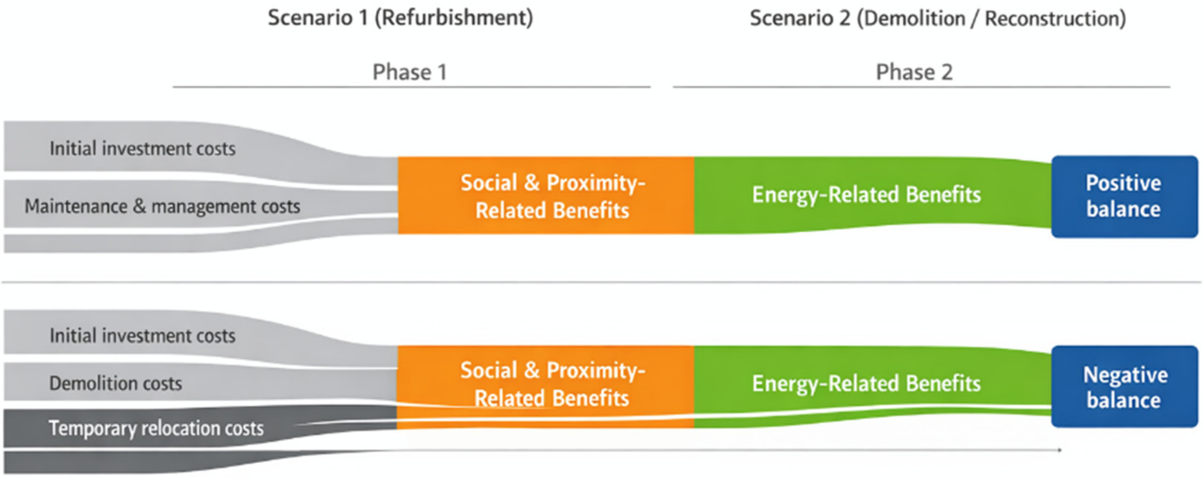

Figure 2. Sankey diagram.

4.4. Phase 2 Results—Energy Benefits: Quantification and Monetization

In a second phase, the potential energy savings deriving from the two intervention scenarios were integrated into the ACB. Specifically, the current energy performance of the buildings was considered, along with the potential savings achievable through the implementation of the energy measures proposed in the two scenarios.

For the current state, a typical building in energy class F was assumed, with

- Annual total consumption: 5,516,592 kWh;
- Estimated annual cost: EUR 784,503.51.

For Scenario 1, an improvement of two energy classes (≈class D) was assumed, achievable through

- Thermal insulation of the building envelope;
- Replacement of windows and doors;
- Installation of a photovoltaic system.

For Scenario 2, a newly constructed building in energy class A3 was assumed.

Comparison of ex ante and ex post consumption reveals the following potential energy savings:

- Scenario 1: −43% of annual consumption;
- Scenario 2: −84% of annual consumption.

These savings were monetized and integrated into the ACB [21].

The effects on the main economic indicators are as follows:

Scenario 1

- NPV becomes positive, showing an overall economic advantage for the first time.
- The IRR could therefore be calculated and is higher than the applied discount rate.
- The discounted benefit–cost ratio (BCR) exceeds unity.
- The Payback Period (PBP) falls within the 30-year reference horizon

Scenario 2

- NPV remains negative, despite the substantial energy savings.
- BCR remains below 1.
- PBP exceeds 60 years, which is inconsistent with the public investment perspective.
- IRR was not calculated due to the persistence of negative NPV.

4.5. Comparison Between the Two Scenarios

The second scenario confirms a significantly lower economic and social convenience compared to Scenario 1, both in Phase 1 and Phase 2.

Refurbishment emerges as the most advantageous option overall, considering

- Lower initial costs;
- Reduced environmental impacts (absence of demolition waste);
- Positive energy balance;
- Faster and more targeted social effects.

Even after integrating energy benefits, Scenario 2 does not achieve acceptable values for NPV, BCR, and PBP, whereas Scenario 1 becomes fully sustainable (Table 8).

Table 8. Summary of Cost–Benefit Analysis Results: Phase 1 and Phase 2.

Indicators	**Scenario 1 Phase 1**	**Scenario 2 Phase 1**	**Scenario 1 Phase 2**	**Scenario 2 Phase 2**
NPV	−5,100,922.89	−75,303,975	564,717.78	−64,838,897.04
BCR	0.78	0.32	1.02	0.42
PBP	~45 anni	0.32	≈30 anni	>60 anni
IRR	n.d. [1]	>60	4.99%	n.d.

Source: [1] the internal rate of return (IRR) cannot be determined because the project yields a negative Net Present Value (NPV).

The CBA proved to be crucial in showing that social benefits alone are not sufficient to justify an investment; it is instead necessary to include less immediate but systemic benefits, such as energy savings, within the evaluation framework [21,22,39].

The integration of energy-related benefits—such as reduced energy consumption, lower emissions, and improved efficiency—can overturn the overall assessment of feasibility, as demonstrated by Scenario 1. This approach fits within the broader logic of a social/energy-oriented CBA, which accounts for positive externalities beyond traditional financial flows [7,21,22].

However, energy efficiency alone is not always sufficient to offset high initial investment costs, as clearly shown by the experience of Scenario 2. This highlights the need to carefully consider investment costs, realistic consumption dynamics, the time horizon, and the difficulty of capturing returns that are too diluted over time—elements that are critical in a robust CBA [41].

The comparative analysis clearly shows that the inclusion of energy-related benefits substantially alters the relative desirability of the two regeneration strategies. While social benefits alone are insufficient to justify either intervention, the integration of long-term energy savings shifts the overall assessment in favor of refurbishment-oriented solutions, which appear more compatible with public budget constraints and sustainability objectives.

Although Scenario 2 provides a larger total floor area and additional facilities such as underground parking, the comparison between the two scenarios is consistent with the logic of public decision-making, which typically involves choosing among alternative investment strategies rather than technically equivalent solutions. The Cost–Benefit Analysis does not aim to normalize outputs per square metre, but to assess whether the additional benefits generated by a more capital-intensive intervention justify the substantially higher public investment required. In this perspective, the scenarios represent realistic policy alternatives for the regeneration of the same public housing asset, reflecting different strategic approaches rather than equivalent design options [21,40,45].

In conclusion, among the two hypotheses analyzed, Scenario 1 emerges as the more balanced and recommendable option, as it combines economic, energy and social sustainability with a lower environmental impact, by avoiding demolition activities and waste disposal [3].

Ultimately, the framework is designed to support informed policy choices by making trade-offs across dimensions explicit. Decision-makers can interpret the results by identifying scenarios that perform adequately on social criteria and then evaluating whether additional environmental and economic benefits justify higher public investment. This approach reflects real-world public sector decision processes, where multiple objectives are addressed through transparent comparison rather than optimization.

4.6. Sensitivity Analysis Results

The sensitivity analysis was carried out with the aim of testing the robustness of the results obtained in the two stages of the Cost–Benefit Analysis (CBA), by assessing how reasonable variations in key parameters may affect the main economic–financial indicators (NPV, BCR, PBP and IRR).

This procedure is consistent with the methodological guidance provided by the Guide to Cost–Benefit Analysis of Investment Projects of the European Commission [21].

Three groups of variables were examined:

- Discount rate (±1%);
- Investment costs and energy costs (±10%);
- Monetised social benefits (±15%).

These variation ranges reflect standard practice in public investment appraisal and are consistent with the methodological guidance provided by the European Commission for ex ante project evaluation [21].

The sensitivity analysis was applied to both Phase 1 (social benefits only) and Phase 2 (social and energy benefits combined).

Variation in the Discount Rate (±1%)

Scenario 1

- Phase 1: The variation in the discount rate produces only a marginal change in the NPV, which nevertheless remains negative.
- Phase 2: With the inclusion of energy savings, the NPV remains positive even when the discount rate is increased.
    - With a +1% discount rate, the NPV decreases but stays positive, confirming the economic resilience of the scenario.
    - With a −1% discount rate, the NPV increases further, and the IRR maintains an adequate safety margin.

Scenario 2

In both phases, a variation in the discount rate is not sufficient to turn the NPV positive.

The project remains economically unsustainable even under the most favourable assumption (−1%).

Result: the discount rate does not emerge as a critical factor in the choice between the two scenarios; Scenario 1 remains clearly more robust than Scenario 2.

Variation in Costs (±10%)

Cost variation is the parameter that generates the most significant effects.

Scenario 1

- Phase 1: the NPV remains negative even in the case of a 10% reduction in costs, confirming that social benefits alone do not ensure economic convenience.
- Phase 2: With costs −10%, the NPV increases markedly, with improvements in both the BCR and the PBP. With costs +10%, the NPV decreases but remains positive, demonstrating a good level of economic stability for the scenario.

Scenario 2

Even with a −10% reduction in costs, the NPV remains negative in both phases.

The BCR never reaches unity, and the PBP continues to exceed 60 years by a wide margin.

Result: only Scenario 1 shows an acceptable level of resilience to cost variations, while Scenario 2 remains economically unattractive under all configurations.

Variation in Social Benefits (±15%)

Scenario 1

- Phase 1:
    - With a +15% increase in social benefits, the NPV improves but does not cross the threshold of economic feasibility.
    - With a −15% variation, the NPV worsens further.
- Phase 2: the variation has a moderate effect, but the NPV remains consistently positive, indicating that economic feasibility is driven mainly by energy-related benefits.

Scenario 2

The variation in social benefits, even under the +15% assumption, does not alter the negative nature of the NPV.

Result: social benefits have only a marginal influence on economic feasibility; in Phase 2, the truly decisive element is energy savings.

Table 9 provides a concise overview of the results obtained.

The sensitivity analysis confirms what had already emerged from the results assessment:

- Scenario 1 proves to be robust and stable, maintaining economic feasibility even under adverse conditions, such as an increase in the discount rate or higher investment costs).
- Scenario 2 is structurally unsustainable, as even highly favourable variations in the parameters do not alter the negative nature of the NPV.
- In Phase 2, the decisive factor is energy savings, which drive the shift in Scenario 1 from economically unfeasible to financially viable.
- Social indicators, while relevant and informative, do not represent the determining element in economic–financial feasibility.

Table 9. Summary results of the sensitivity analysis for Scenario 1 and Scenario 2.

Parameter	Scenario 1—Fase 1	Scenario 1—Fase 2	Scenario 2—Fase 1	Scenario 2—Fase 2
Discount rate ± 1%	NPV always negative	NPV remains positive	NPV always negative	NPV always negative
Costs ± 10%	Does not change the lack of feasibility	NPV positive even with +10% costs	Always not feasible	Always not feasible
Social benefits ± 15%	Not sufficient to make NPV positive	NPV always positive	Always not feasible	Always not feasible
Overall stability	Low	High	Very low	Very low

5. Discussion

From a theoretical perspective, the proposed two-phase Cost–Benefit Analysis contributes to the literature on ex-ante evaluation by explicitly separating social and energy-related benefits within a single analytical framework. This structure enhances transparency and allows a clearer interpretation of how different categories of impacts influence the overall feasibility of public regeneration interventions. The approach responds to longstanding critiques of conventional CBA by addressing its tendency to obscure non-market benefits within aggregated monetary indicators.

The results of the comparative evaluation highlight the importance of adopting integrated and policy-oriented assessment frameworks when addressing the regeneration of public residential assets. In line with established approaches in planning evaluation, ex-ante appraisal tools support decision-making processes that must reconcile economic feasibility, social outcomes, and long-term territorial impacts, positioning evaluation as an integral component of the planning process rather than a purely technical exercise [61].

From this perspective, the concept of public value provides a useful interpretative lens for understanding the broader implications of regeneration strategies. Public housing interventions generate value not only through direct financial returns, but also through improvements in social cohesion, accessibility, environmental quality, and collective well-being. The results confirm that regeneration strategies oriented towards refurbishment and adaptive reuse are more consistent with a public value–oriented approach, as they enhance existing assets while responding to community needs and institutional responsibilities [62]. This perspective is also coherent with mission-oriented policy frameworks, which emphasize the strategic role of public action in steering innovation and investment towards socially desirable objectives rather than short-term efficiency alone [63].

The complexity of regeneration processes and the plurality of objectives involved inevitably challenge the adequacy of single-criterion economic evaluation tools. Although Cost–Benefit Analysis remains a cornerstone of public appraisal, its effectiveness increases when embedded within a broader decision-support architecture capable of addressing multiple, and sometimes conflicting, objectives. Multi-criteria decision analysis provides a well-established methodological foundation for structuring such complexity, enabling the explicit consideration of trade-offs, stakeholder preferences, and value judgments in decision-making processes [64–68]. In the context of urban regeneration, multi-criteria approaches have been widely applied to support shared development strategies, particularly in inner and marginal areas where social, cultural, and environmental dimensions play a decisive role [69,70].

Multi-criteria decision analysis and Social Return on Investment approaches provide complementary perspectives by incorporating stakeholder preferences and social value considerations, although they often involve higher subjectivity or data requirements [64–75]. In this context, the proposed two-phase Cost–Benefit Analysis strengthens analytical transparency and operational replicability by integrating monetizable social and energy-related benefits within an appraisal structure aligned with EU evaluation guidance [21,45].

Overall, the discussion confirms that the evaluation of urban regeneration strategies cannot be reduced to purely financial performance but requires an integrated perspective capable of accounting for social externalities, energy efficiency gains, and governance-related effects. By situating economic appraisal within a multidimensional decision-support structure, the proposed framework reinforces the role of ex-ante assessment as a key instrument for guiding sustainable, equitable, and policy-relevant public housing regeneration decisions [72–74,76].

The results of the Cost–Benefit Analysis have direct implications for public decision-makers involved in the design, selection, and financing of social housing regeneration programmes. By explicitly quantifying economic, energy-related, and selected social impacts, the proposed framework supports the prioritization of refurbishment-oriented interventions in contexts characterized by financial constraints, social vulnerability, and sustainability objectives.

In the investigated case, inputs collected during the two public hearings conducted in the preliminary phases of the assessment informed the interpretation of social benefits and supported the relative weighting of evaluation criteria within the decision-making process, demonstrating how stakeholder engagement can be operationally integrated into ex-ante appraisal frameworks, how resident participation can be operationally translated into decision-weight allocation, and strength the link between empirical findings and policy instrument design.

In the investigated case study, resident participation was not treated as a generic normative principle but was operationally embedded within the ex-ante evaluation process. Two public hearings conducted during the preliminary phases of the assessment involved residents, local stakeholders, and representatives of the public housing authority. These consultation moments contributed to identifying priority needs—such as housing continuity, proximity services, and the preservation of existing social networks—which directly informed the selection and monetization of social benefits included in Phase 1 of the cost–benefit analysis.

From a policy design perspective, this approach illustrates how participatory mechanisms can be translated into decision-support tools by influencing the allocation of decision weights among stakeholders. While the final decision-making responsibility remains with public authorities, inputs collected through structured consultation processes can be incorporated into ex-ante appraisal frameworks by shaping the relative importance attributed to social continuity, service accessibility, and short-term disruption costs. In the present case, these elements contributed to strengthening the relative performance of the refurbishment-oriented scenario compared to demolition and reconstruction, particularly in the social-only evaluation phase.

More broadly, the findings suggest that ex-ante evaluation tools such as Cost–Benefit Analysis can act as mediating instruments between participatory processes and policy instruments, provided that stakeholder inputs are explicitly linked to the construction of benefit categories and to the interpretation of results. Rather than substituting formal decision-making, participation contributes to increasing transparency and accountability by clarifying how social preferences and community priorities affect the ranking of alternatives. In this sense, resident participation becomes an integral component of policy instrument design, supporting more robust, context-sensitive, and publicly legitimate regeneration strategies in social housing contexts.

From an operational perspective, the two-phase structure can be effectively integrated into public funding schemes, competitive calls, and policy-driven programmes for urban regeneration. The preliminary screening phase may serve as an eligibility and pre-selection tool, while the Cost–Benefit Analysis provides a transparent basis for ranking projects, defining investment priorities, and supporting funding allocation decisions in line with EU appraisal practices [21,45]. At the policy level, the framework strengthens evidence-based governance and supports alignment with broader sustainability objectives, including those articulated in the 2030 Agenda for Sustainable Development [76,77].

6. Conclusions and Future Works

This study highlights the importance of integrated ex-ante evaluation tools in supporting public decision-making processes for the regeneration of public residential assets, particularly in contexts characterized by social vulnerability and limited financial resources. Through the application of a two-phase Cost–Benefit Analysis framework to alternative regeneration strategies, the research shows how the combined consideration of social, economic, and energy-related dimensions can substantially influence the overall assessment of feasibility and public value creation.

The results indicate that refurbishment-oriented strategies, when coupled with targeted energy efficiency measures and proximity-based services, are more effective in achieving a balanced alignment between sustainability objectives, economic viability, and social outcomes than demolition-and-reconstruction approaches. Beyond the specific case study, the proposed evaluation framework demonstrates a high degree of transferability and adaptability to other Mediterranean and Southern European contexts, where ageing public housing stock and structural constraints call for decision-support tools capable of capturing both tangible and intangible impacts.

Future research may further enhance the proposed approach by strengthening the integration of Cost–Benefit Analysis with complementary evaluation frameworks, with particular attention to the dynamic assessment of social effects, long-term environmental externalities, and governance-related dimensions. Advancing hybrid and multidimensional evaluation models represents a promising direction for improving the robustness, inclusiveness, and policy relevance of decision-support tools in sustainable urban regeneration processes.

Despite these contributions, some limitations of the study should be acknowledged. First, the ex-ante nature of the evaluation inevitably relies on assumptions regarding user behaviour, social interactions, and future socio-economic dynamics, which may evolve over time and differ across local contexts. In particular, cultural factors, informal social networks, and community-specific practices—often crucial in public housing environments—are only partially captured through monetizable indicators and simplified proxies [71,74]. Moreover, potential interaction effects among social, environmental, and economic variables are addressed in a simplified manner, consistent with standard Cost–Benefit Analysis practice, but deserving of further methodological refinement [41,44].

Future research should therefore focus on enhancing the capacity of evaluation frameworks to account for dynamic social processes, cultural dimensions, and stakeholder interactions, possibly through the integration of participatory and multi-criteria approaches within ex-ante appraisal models [60,64–68,72]. Longitudinal analyses and ex-post evaluations would also be valuable in validating the assumptions adopted and in assessing the long-term impacts of regeneration strategies on social cohesion, energy performance, and territorial resilience. These developments would contribute to strengthening the empirical robustness and policy relevance of integrated evaluation tools for public housing regeneration.

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Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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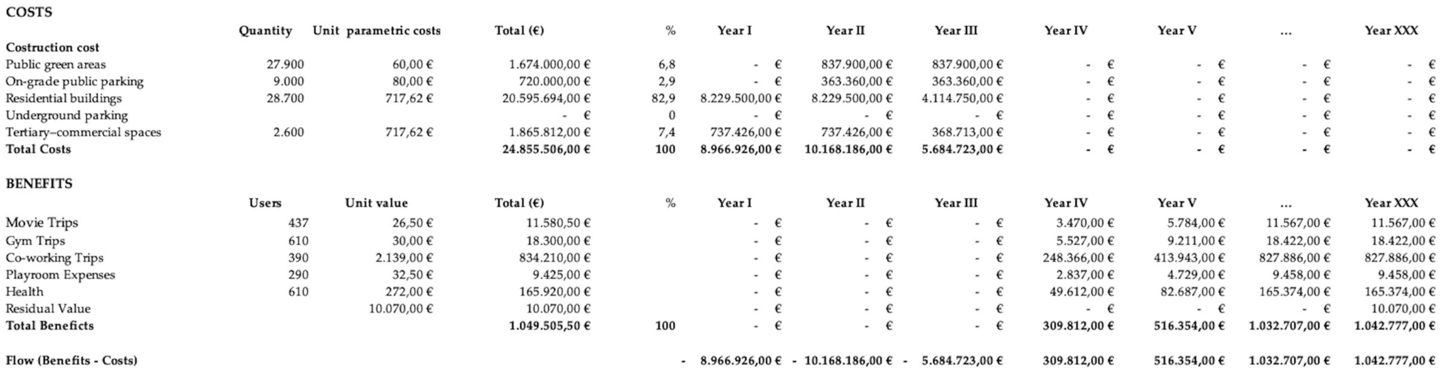
Appendix A

(All amounts are expressed in the Italian monetary system (Euro). Decimal commas and period separators follow Italian conventions).

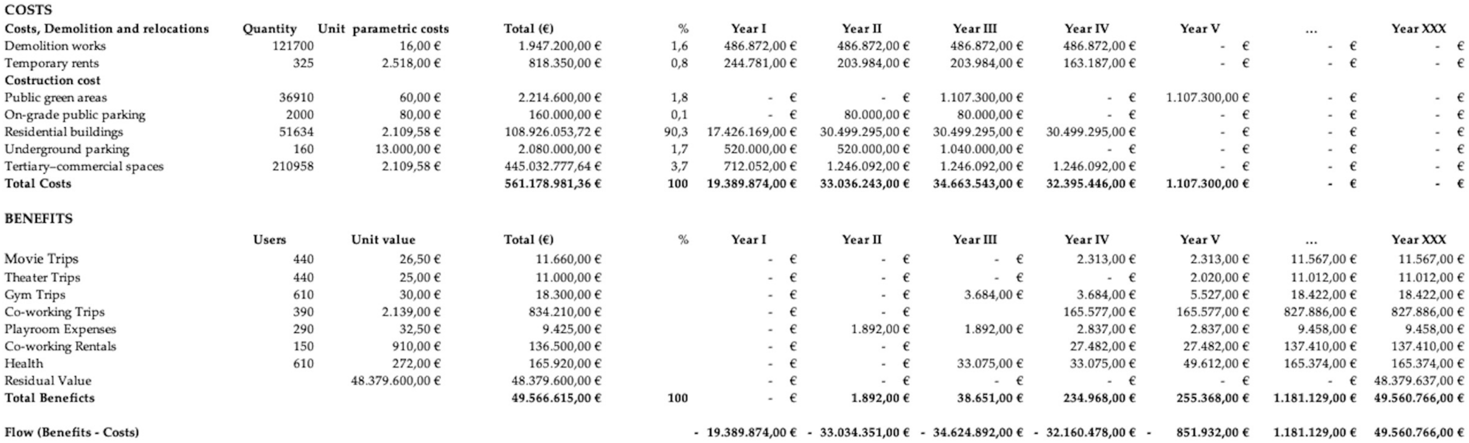
Appendix A.1



COSTS											
	Quantity	**Unit parametric costs**	**Total (€)**	**%**	**Year I**	**Year II**	**Year III**	**Year IV**	**Year V**	**…**	**Year XXX**
Costruction cost											
Public green areas	27.900	60,00 €	1.674.000,00 €	6,8	- €	837.900,00 €	837.900,00 €	- €	- €	- €	- €
On-grade public parking	9.000	80,00 €	720.000,00 €	2,9	- €	363.360,00 €	363.360,00 €	- €	- €	- €	- €
Residential buildings	28.700	717,62 €	20.595.694,00 €	82,9	8.229.500,00 €	8.229.500,00 €	4.114.750,00 €	- €	- €	- €	- €
Underground parking			- €	0	- €	- €	- €	- €	- €	- €	- €
Tertiary–commercial spaces	2.600	717,62 €	1.865.812,00 €	7,4	737.426,00 €	737.426,00 €	368.713,00 €	- €	- €	- €	- €
Total Costs			**24.855.506,00 €**	**100**	**8.966.926,00 €**	**10.168.186,00 €**	**5.684.723,00 €**	**- €**	**- €**	**- €**	**- €**
BENEFITS											
	Users	**Unit value**	**Total (€)**	**%**	**Year I**	**Year II**	**Year III**	**Year IV**	**Year V**	**…**	**Year XXX**
Movie Trips	437	26,50 €	11.580,50 €		- €	- €	- €	3.470,00 €	5.784,00 €	11.567,00 €	11.567,00 €
Gym Trips	610	30,00 €	18.300,00 €		- €	- €	- €	5.527,00 €	9.211,00 €	18.422,00 €	18.422,00 €
Co-working Trips	390	2.139,00 €	834.210,00 €		- €	- €	- €	248.366,00 €	413.943,00 €	827.886,00 €	827.886,00 €
Playroom Expenses	290	32,50 €	9.425,00 €		- €	- €	- €	2.837,00 €	4.729,00 €	9.458,00 €	9.458,00 €
Health	610	272,00 €	165.920,00 €		- €	- €	- €	49.612,00 €	82.687,00 €	165.374,00 €	165.374,00 €
Residual Value		10.070,00 €	10.070,00 €		- €	- €	- €	- €	- €	- €	10.070,00 €
Total Beneficts			**1.049.505,50 €**	**100**	**- €**	**- €**	**- €**	**309.812,00 €**	**516.354,00 €**	**1.032.707,00 €**	**1.042.777,00 €**
Flow (Benefits - Costs)					**- 8.966.926,00 €**	**- 10.168.186,00 €**	**- 5.684.723,00 €**	**309.812,00 €**	**516.354,00 €**	**1.032.707,00 €**	**1.042.777,00 €**

Figure A1. Cost–Benefit Analysis, Scenario 1: Cash Flow Analysis.

Appendix A.2



COSTS											
Costs, Demolition and relocations	**Quantity**	**Unit parametric costs**	**Total (€)**	**%**	**Year I**	**Year II**	**Year III**	**Year IV**	**Year V**	**…**	**Year XXX**
Demolition works	121700	16,00 €	1.947.200,00 €	1,6	486.872,00 €	486.872,00 €	486.872,00 €	486.872,00 €	- €	- €	- €
Temporary rents	325	2.518,00 €	818.350,00 €	0,8	244.781,00 €	203.984,00 €	203.984,00 €	163.187,00 €	- €	- €	- €
Costruction cost											
Public green areas	36910	60,00 €	2.214.600,00 €	1,8	- €	- €	1.107.300,00 €	- €	1.107.300,00 €	- €	- €
On-grade public parking	2000	80,00 €	160.000,00 €	0,1	- €	80.000,00 €	80.000,00 €	- €	- €	- €	- €
Residential buildings	51634	2.109,58 €	108.926.053,72 €	90,3	17.426.169,00 €	30.499.295,00 €	30.499.295,00 €	30.499.295,00 €	- €	- €	- €
Underground parking	160	13.000,00 €	2.080.000,00 €	1,7	520.000,00 €	520.000,00 €	1.040.000,00 €	- €	- €	- €	- €
Tertiary–commercial spaces	210958	2.109,58 €	445.032.777,64 €	3,7	712.052,00 €	1.246.092,00 €	1.246.092,00 €	1.246.092,00 €	- €	- €	- €
Total Costs			**561.178.981,36 €**	**100**	**19.389.874,00 €**	**33.036.243,00 €**	**34.663.543,00 €**	**32.395.446,00 €**	**1.107.300,00 €**	**- €**	**- €**
BENEFITS											
	Users	**Unit value**	**Total (€)**	**%**	**Year I**	**Year II**	**Year III**	**Year IV**	**Year V**	**…**	**Year XXX**
Movie Trips	440	26,50 €	11.660,00 €		- €	- €	- €	2.313,00 €	2.313,00 €	11.567,00 €	11.567,00 €
Theater Trips	440	25,00 €	11.000,00 €		- €	- €	- €	- €	2.020,00 €	11.012,00 €	11.012,00 €
Gym Trips	610	30,00 €	18.300,00 €		- €	- €	3.684,00 €	3.684,00 €	5.527,00 €	18.422,00 €	18.422,00 €
Co-working Trips	390	2.139,00 €	834.210,00 €		- €	- €		165.577,00 €	165.577,00 €	827.886,00 €	827.886,00 €
Playroom Expenses	290	32,50 €	9.425,00 €		- €	1.892,00 €	1.892,00 €	2.837,00 €	2.837,00 €	9.458,00 €	9.458,00 €
Co-working Rentals	150	910,00 €	136.500,00 €		- €	- €		27.482,00 €	27.482,00 €	137.410,00 €	137.410,00 €
Health	610	272,00 €	165.920,00 €		- €	- €	33.075,00 €	33.075,00 €	49.612,00 €	165.374,00 €	165.374,00 €
Residual Value		48.379.600,00 €	48.379.600,00 €		- €	- €	- €	- €	- €	- €	48.379.637,00 €
Total Benefits			**49.566.615,00 €**	**100**	**- €**	**1.892,00 €**	**38.651,00 €**	**234.968,00 €**	**255.368,00 €**	**1.181.129,00 €**	**49.560.766,00 €**
Flow (Benefits - Costs)					**- 19.389.874,00 €**	**- 33.034.351,00 €**	**- 34.624.892,00 €**	**- 32.160.478,00 €**	**- 851.932,00 €**	**1.181.129,00 €**	**49.560.766,00 €**

Figure A2. Analysis of Cost–Benefit Scenario 2—Cash Flow Anaysis.

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