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Analyzing Cost Efficiency and Project Scope in Post-Disaster Housing: Reconstruction Cases of TOKI in Türkiye

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Abstract: The Mass Housing Administration of Türkiye (TOKI) operates as the primary public organization responsible for delivering extensive affordable housing throughout Türkiye while ensuring disaster resilience. The recent decades of earthquakes and environmental hazards in Türkiye have necessitated extensive post-disaster reconstruction initiatives nationwide. In response, TOKI has completed numerous disaster housing projects across the country through an integrated infrastructure framework supporting community recovery. This study presents an extensive statistical evaluation of 664 disaster housing projects constructed by TOKI across 40 provinces. Specifically, a quantitative analysis is conducted on 434 disaster housing projects for which detailed financial data are available. This research examines differences in construction costs between urban mass housing developments and rural village settlements, particularly focusing on the integration of functional structures such as schools, mosques, commercial units, and barns. Although mass housing projects require significantly larger total budgets due to their extensive scale, statistical analysis reveals no significant difference in per-unit construction costs between mass housing and village housing projects. Regression analysis indicates that incorporating barns increased per-unit construction costs, while the presence of schools and mosques significantly decreases these expenses. The findings of this research provide critical insights into the economic and functional factors influencing disaster housing reconstruction in Türkiye and offer practical recommendations for improved planning, resource management, and community reconstruction based on an evaluation of functional structures.

Keywords: construction cost; earthquake reconstruction; project scope; post-disaster housing; TOKI; Türkiye

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1. Introduction

Türkiye's construction sector has faced numerous challenges due to economic fluctuations and natural disasters over the past several years. Principally, the pandemic-triggered global economic downturn negatively impacted construction costs, leading to significant price increases for materials and labor [1]. The Turkish Statistical Institute (TUIK) reported that construction costs increased by 15.32% within a month and by 78.52% compared to the same month in the previous year in January 2023 [2]. Moreover, material costs showed a monthly increase of 5.79%, but labor costs experienced a dramatic surge of 47.79%, indicating extreme inflation in construction resources [2]. In this respect, increasing costs pose significant challenges to conducting post-disaster recovery and reconstruction operations as budgets remain constrained. When economic instability occurs, alternative building techniques, budgeting strategies, and cost control methods must be adopted immediately [1,3]; however, natural disasters can potentially affect any country.

In fact, a double earthquake disaster struck Kahramanmaraş province on 6 February 2023, with major tremors reaching 7.8 and 7.5 magnitudes, which caused extensive destruction across eleven provinces of the southern region [4–6]. Official assessments of building damage in March 2023 showed widespread destruction throughout the affected areas. Accordingly, more than 1,712,000 inspected buildings showed that 35,355 had complete destruction. In addition, the inspection revealed that 179,786 buildings suffered severe structural damage, which required immediate demolition, alongside 17,491 buildings that suffered from major structural damage. More than 179,786 buildings suffered heavy damage, 40,228 suffered moderate damage, and 431,421 buildings received minor damage [7]. Unfortunately, the death toll from the disaster reached more than 50.000 with over 115,000 injured people and economic damage estimated at USD 103.6 billion, representing 9% of Türkiye's Gross Domestic Product (GDP) [7].

Therefore, the disaster has highlighted the immediate requirement for the construction sector to provide secure housing solutions to earthquake survivors while also creating pressure on governmental agencies to act quickly [8,9]. Emergency management agencies face a vital challenge in providing disaster housing after natural disasters because they need fast yet practical solutions to relocate vulnerable populations [10]. The destruction of homes and critical infrastructure following disasters necessitates the rapid deployment of temporary shelter solutions to establish livable environments for affected communities [10].

The provision of temporary housing serves as a vital intervention, as it establishes a safe and sanitary environment that enables displaced individuals to rebuild their lives with personal space and dignity before more permanent housing becomes accessible [11]. However, the emergency shelters built with tents and prefabricated structures provide instant protection from weather elements, and transitional shelters deliver sustainable housing solutions during the ongoing recovery phase. Designing temporary dwellings requires evaluating multiple variables, such as climate elements and cultural practices, in conjunction with available regional materials to create shelters that function well and align with local traditions [12,13]. Moreover, the selection of temporary housing for displaced populations must consider their socioeconomic impact since efficient planning minimizes disruptions. The duration of using temporary housing facilities should be determined based on realistic estimates of permanent restoration timelines or new house construction periods [11].

After temporary housing solutions such as tents and containers are provided, it is essential to ensure that people can live in a safe and permanent housing environment; the reconstruction activities have started in Türkiye. To achieve this, before the construction projects' bids were started, the Turkish authorities implemented regulatory changes to enhance building safety and resilience. Another change made in the zoning regulations adopted in July 2023 is that only architects and engineers with higher qualifications were allowed to engage in post-disaster reconstruction projects [7]. These professionals were required to have a minimum of 5 years of experience, with a proven track record of designing at least four buildings exceeding 10,000 square meters in area. Mechanical engineers responsible for high-rise or large public buildings must have demonstrated substantial practical experience, ensuring the highest level of expertise in the field [7]. After the amendments to the regulations, the Ministry of Environment and Urbanization, together with the Mass Housing Agency, launched the procurement procedures for disaster housing projects.

TOKI (Toplu Konut İdaresi Başkanlığı), established in 1984 and currently a public institution under the Presidency, has emerged as the primary state body overseeing post-disaster housing recovery in Türkiye. Over the past two decades, TOKI has constructed over 1.2 million housing units nationwide, significantly enhancing the availability of affordable housing and promoting urban renewal [14]. In response to the 2023 earthquakes, TOKI has developed plans to construct approximately 650,000 new permanent homes, including mass housing and village-style houses, with the goal of delivering about 319,000 of these units within the first year following the disaster [7].

Furthermore, the research has shown that an agile approach to project planning, which involves building community trust and offering a range of material and technological options, can significantly enhance the long-term effectiveness of reconstruction projects [15,16]. While these criteria are not technical design requirements, they can serve as a valuable starting point for further project development [15–17]. Other research on post-disaster reconstruction has identified several common challenges that can lead to delays and increased costs, including contractors' failures, design changes, the use of low-bid contracts, and security concerns in conflict-prone areas [17,18].

To mitigate these recurring issues, the Turkish government has introduced stricter eligibility criteria. These measures aim to minimize performance-related risks associated with contractors and design professionals involved in reconstruction projects [7]. Accordingly, TOKI (the Housing Development Administration of Türkiye) has been granted the authority to initiate public tenders and, under the supervision of the Ministry of Environment and Urbanization, tasked with identifying qualified construction companies and expediting the commencement of building processes.

Given the central role of TOKI in post-disaster reconstruction efforts, understanding the financial and functional dimensions of its housing projects has become increasingly important. In this context, the current study aims to explore the economic aspects of Türkiye's post-disaster housing projects, focusing on how the type of project and the incorporation of other facilities impact the total project costs. In this study, "project functionality" refers to the presence of facilities such as schools, mosques, commercial units, agricultural barns, and storage depots within housing developments. Furthermore, the project size and location are distinguished into large-scale urban "mass housing" projects and small, rural "village housing" projects. These distinctions align with Türkiye's ongoing reconstruction strategy, which includes the use of densely built urban apartment blocks for urban populations and scattered, village-type houses for rural survivors who wish to remain near their original settlements [7].

The common perception that functional structures and extensive infrastructure increase construction costs in housing projects may be incorrect because large-scale urban developments could achieve lower per-unit expenses through economies of scale than smaller village-based projects [19,20]. The current literature fails to provide detailed quantitative assessments of financial trade-offs, specifically in Türkiye's post-disaster reconstruction initiatives.

The research examines 664 TOKI disaster housing projects through statistical analysis across 40 provinces to study project scope and cost patterns. We focuses on 434 projects that have full financial records for analysis through quantitative methods. We examine cost differences through an evaluation of project type between mass housing and village housing, as well as facility functionality and geographic location. Descriptive statistics together with correlation analysis and comparative assessments are used to determine how different factors affected total project costs. Results offer valuable guidance for future Turkish post-disaster housing reconstruction efforts by helping to optimize cost-effectiveness and functional requirements.

2. Literature Review

Natural disasters produce distinctive patterns which affect both residential structures and population relocation across nations. Moreover, earthquakes surprise people before destroying buildings across the affected zone. As a result, the sudden nature of house destruction in seismic disasters requires cities to rebuild everything entirely [13]. The Kahramanmaraş earthquakes that struck Türkiye on 6 February 2023 caused widespread damage to reinforced concrete buildings and historic structures and masonry structures, thus becoming "the disaster of the century" for the country [4–6,21]. The earthquake disaster impacted approximately 14 million residents and caused extensive property damage across Türkiye [22].

The 2015 Gorkha earthquake, with its magnitude of 7.6, caused severe damage to homes throughout all 32 mountain districts of Nepal. The landslides created 20,000 events which eliminated several villages from the map while destroying most housing structures, compelling numerous families to relocate from dangerous areas [23]. The affected populations demonstrated strong resilience despite these challenges as they learned to adapt to the permanent land use changes caused by fault ruptures and landslides which required settlements to move [23].

The Great East Japan Earthquake (GEJE) of 2011 stands as another disaster example that caused severe damage to both physical structures and social economic frameworks which provided valuable lessons for reconstruction activities. The earthquake measured 9.0 on the Richter scale and produced a destructive tsunami that destroyed homes and vital facilities and forced thousands of people to relocate before starting a prolonged recovery process. The Japanese government launched a reconstruction plan that combined streamlined regulatory systems with inland relocation of coastal areas to minimize future disaster risks. The Japanese recovery process received significant acceleration from public–private partnerships which also showed the advantages of private sector participation. The GEJE shows that nations facing post-disaster reconstruction need well-organized governance systems together with risk management approaches and continuous financial support [1,3,24].

All disaster recovery approaches begin by providing emergency relief which then leads to long-term reconstruction efforts regardless of the hazard type. After any disaster, the primary requirement becomes providing temporary housing to affected persons [25]. The initial emergency response typically involves rapidly deploying tents and provisional shelters. The 2009 earthquake in L'Aquila in Italy led authorities to build 5957 tents across 171 camps which sheltered more than 35,000 people while simultaneously moving thousands to hotel accommodations as temporary housing [26]. The effective management of disasters requires accurate assessments of both direct structural damages and indirect socioeconomic recovery expenses, especially those concerning temporary housing support, according to Di Ludovico et al. (2021) [27]. The researchers studied the 2009 L'Aquila earthquake through detailed analysis which revealed indirect costs of temporary housing solutions equal to those of direct repair or rebuilding expenses for moderately damaged buildings [27]. Post-disaster reconstruction planning becomes more efficient and sustainable through comprehensive indirect cost assessments according to this discovery [15].

The duration of emergency tent usage extends from weeks to months because these structures serve only to shield people from environmental factors. The prolongation of tent usage occurs because reconstruction delays force residents to endure harsh living conditions from substandard shelters which lack durability and insulation and create unpleasant dwelling environments. Due to the acknowledged limitations of emergency shelters, transitional housing solutions are often prioritized in disaster recovery plans [19]. Transitional shelters made from prefab or modular units including wooden huts and containers provide both rapid installation and improved safety and personal space and superior comfort levels compared to tent accommodations [25]. During the L'Aquila response, the Italian government introduced Moduli Abitativi Provvisori (MAP) as transitional accommodations through the installation of temporary wooden houses and modular units. The recovery process included 3166 M.A.P. units which consisted of small wood-frame houses that established 1113 units in L'Aquila city for 3300 people and other units in surrounding towns as stronger alternatives before permanent homes became available [26].

Effective housing recovery relies on a rigorous policy framework and strong institutional support to implement various strategies. Housing reconstruction speeds and fairness depend on proper governance systems that determine these processes [8]. Japan learned from past disasters, including the 2011 Great East Japan Earthquake (GEJE), that it must create legal frameworks together with planning protocols before disasters strike. Japan established special reconstruction zones following the 2011 GEJE to expedite land-use planning and environmental assessments for quick housing construction [24]. The recovery efforts used public–private partnerships (PPPs) to accelerate reconstruction through private firms which took charge of land acquisition and housing design and construction in integrated packages to boost efficiency and capacity [20,22].

When vulnerable populations remain excluded from policy frameworks, it not only leads to unsuccessful recovery outcomes but also highlights the need for more inclusive policies. The U.S. faced substantial policy gaps in its post-disaster housing programs after Hurricane Harvey which resulted in neglecting vulnerable populations [9,24]. The effectiveness of a recovery program should be evaluated not only by the quantity of houses constructed but also by its impact on restoring livelihoods and community well-being [8].

Housing recovery initiatives need strategic frameworks based on BBB principles to achieve successful rebuilding that results in stronger sustainable and inclusive infrastructure which reduces future disaster risks. These strategic frameworks provide actionable guidelines aimed at constructing resilient and sustainable futures. Long-term disaster recovery success requires frameworks that include reconstruction master plans and effective governance systems with community-based coordination to achieve sustainability and resilience [10,25].

Turkish disaster housing recovery has depended predominantly on Public–Private Partnerships (PPPs) since the time of seismic disasters. The reconstruction process benefits from such partnerships which unite government institutions with private sector companies and depends heavily on private sector companies which provide essential resources, expertise, and innovative solutions for efficient disaster housing reconstruction [28]. The PPP frameworks accelerated fast and widespread house construction following the Kahramanmaraş earthquakes through the combination of modern building methods with resilience standards and sustainability approaches. These collaborative reconstruction approaches have accelerated the building timeline to produce houses that fulfill advanced disaster resistance standards [11,17].

After using temporary disaster housing, the Ministry of Environment Urbanization and Climate Change of Türkiye issued TOKI (Housing Development Administration of Türkiye) with responsibility for permanent housing programs. The permanent housing projects were put out for tender to private construction firms who could use their skills and capabilities to speed up recovery operations. In keeping with the BBB (Build Back Better) principles, the reconstruction activities carried out in Türkiye following seismic events have had a specific focus on constructing stronger, safer, and more resilient housing structures [29]. For instance, the TOKI-led reconstruction of the Kahramanmaraş earthquakes included structural improvements and enhanced seismic safety measures as well as sustainable urban planning to lower future disaster risks. Successful housing recovery programs depend on strategic plans which unite BBB principles with reconstruction master plans, governance excellence, and community-based coordination [18,22].

The evaluation of earthquake-related direct and indirect costs serves as a fundamental step for creating effective disaster mitigation plans and sustainable recovery strategies. The 2009 L'Aquila earthquake evidence demonstrates that severe structural damage results in elevated financial costs. The severe structural damage required repair expenses which reached near-full reconstruction levels. The expenses for providing emergency housing ended up being higher than the repair costs for structures with moderate damage levels [27]. The findings demonstrate why economic modeling should be included as a fundamental element in disaster recovery planning. The research extends previous findings about reconstruction costs and housing policies by analyzing direct reconstruction expenses and housing policy measures in the 2023 Kahramanmaraş earthquake region of Türkiye. This methodology aims to solve current gaps by offering precise cost assessments along with policy suggestions that match the distinctive disaster recovery situation of Türkiye.

The worldwide examples show that specific quantitative analyses of the situation in Türkiye are rare. The current research establishes itself as a crucial addition because it analyzes both financial and operational aspects of post-disaster housing projects while addressing a significant knowledge gap and providing essential insights for future reconstruction work in Türkiye.

3. Research Design and Hypothesis Development

The ongoing seismic events in Türkiye combined with increasing requirements for efficient disaster recovery methods require evaluating reconstruction economic aspects during this period. The research provides essential financial insights to policymakers, urban planners, and construction professionals who manage complex recovery operations. The study uses empirical data to guide future choices while enhancing the cost-effectiveness and flexibility of post-disaster housing reconstruction in Türkiye.

The reconstruction projects show significant differences because they vary in size and location and design features between urban apartment complexes and rural village housing schemes.

The research question regarding cost variation between post-disaster housing projects remains an underexplored area of study in the current literature. The implementation of housing projects in practice includes various functional facilities, such as schools, mosques, commercial units, and barns, to enhance community resilience. The added features that enhance housing development functionality and resident quality of life have not received sufficient research on their impact on total and unit-based project expenses. The financial variations in reconstruction programs stem from the differences between large-scale urban developments and smaller rural housing initiatives. Post-disaster reconstruction programs require improved cost-efficiency and adaptability, which necessitates a thorough examination of these essential dimensions.

Thus, this study addresses the following specific research questions (RQs):

RQ 1. Is the number of functional structures included in a project positively correlated with the project's total contract costs?

RQ 2. Are mass urban housing projects generally more expensive in total cost compared to rural village housing projects?

RQ 3. Among different functional structures (mosques, schools, commercial units, and barns), which facility type most substantially influences total project costs?

RQ 4. Do per-unit costs differ systematically between village housing and mass housing projects, and if so, is this difference primarily driven by the presence of rural-specific facilities, such as barns?

Aiming to identify the underlying structural cost elements within post-disaster reconstruction settings in Türkiye, this study examines the project-level data of 664 TOKI-led disaster housing projects, as listed on TOKI's website for disaster housing projects (retrieved January 2025). The research employs a mixed-method approach, with qualitative studies encompassing all 664 initiatives and quantitative cost studies utilizing thorough financial data available for 434 projects.

The following hypotheses are proposed to guide the empirical analysis:

- H1 (Functional Scope): The number of functional structures included in a housing project positively correlates with its overall budget.
- H2 (Project Type—Total Cost): Mass housing projects exhibit significantly higher total budgets compared to village housing projects, primarily due to their more extensive scale and scope.
- H3 (Differentiated Structure Impact): Different functional structures have a distinct impact on project costs. Specifically, barns significantly increase per-unit costs, whereas schools and mosques, typically integrated into larger-scale projects, tend to reduce per-unit expenses through economies of scale.
- H4 (Project Type—Unit Cost): Mass housing projects differ systematically from village housing projects in per-unit costs, but this difference is influenced primarily by the inclusion of specific functional structures (e.g., barns) rather than by project type alone.

The remaining aspects of this work are organized as follows: Section 4 describes in detail the data sources and procedures used in the study. The empirical findings, presented in Section 5, are discussed in the context of the existing literature and their implications in Section 6. These implications are intended to guide decision-making by policymakers, urban planners, and construction professionals. Section 7 presents a conclusion and suggestions for further research that may encourage and channel more research in this area toward potentially important breakthroughs.

4. Materials and Methods

4.1. Data Sources and Project Selection

The project data were derived from official reconstruction records accessible via TOKI's updated website. Each disaster housing project included in the dataset was carefully reviewed to verify completeness and accuracy, enhancing the robustness of the research approach. Moreover, a total of 230 projects were excluded from analysis due to ongoing bidding processes and pending construction initiation. Consequently, the final quantitative sample comprised 434 projects out of an initial 664. As illustrated in Figure 1, this analytical approach enhances both transparency and reproducibility, providing a comprehensive understanding of the criteria guiding disaster housing project selection.

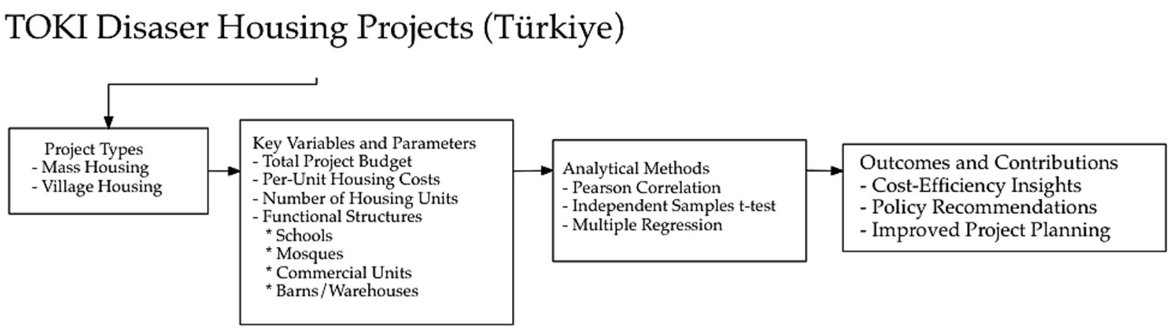

Figure 1. Conceptual research framework highlighting key project types, variables, analytical methods, and expected outcomes.

Table 1 presents ten illustrative examples selected from the final quantitative dataset of 434 TOKI disaster housing projects to provide clarity and practical context about the scope and financial dimensions of the analyzed projects. Indeed, these examples are carefully chosen to reflect a balanced representation of urban and rural projects from diverse geographic regions and varying total budgets, thereby improving research transparency and aiding reader comprehension. This diversity ensures that the research is comprehensive and representative of the entire dataset.

Table 1. Representative TOKI Disaster Housing Projects [30].

No	Project Name and Region	Project Scope	Total Cost (USD)
1	Van Edremit Disaster Zone Phase 18, 480 Permanent Disaster Houses, Primary School (32 Classes), Mosque, and Kiosk	Urban Disaster Housing, Educational Facility, Mosque, and Kiosk	1,341,316
2	Şanlıurfa Province, Birecik District, Çoğan Neighborhood, 534 Houses with Infrastructure and Landscaping	Urban/Suburban Disaster Housing, Infrastructure, and Landscaping	20,202,632
3	Malatya Province, Doğanşehir District, Altıntop Neighborhood, Phase 1, 724 Houses with Infrastructure and Landscaping	Urban Disaster Housing, Infrastructure, and Landscaping	41,776,316
4	Kahramanmaraş Province, Elbistan District, Karaelbistan Neighborhood, Phase 6, 926 Houses with Infrastructure and Landscaping	Urban Disaster Housing, Infrastructure, and Landscaping	44,144,737
5	Hatay Province, Kırıkhan District, Karataş Neighborhood, 830 Houses with Infrastructure and Landscaping	Urban Disaster Housing, Infrastructure, and Landscaping	39,947,368
6	Balıkesir Province, Havran District, 50 Village Houses with Barns, 39 Village Houses, and a Commercial Center with 3 Shops, Infrastructure and Landscaping	Rural Disaster Housing, Barns, Commercial Center, Infrastructure and Landscaping	6,484,211
7	Ardahan Province, Göle and Posof Districts, 68 Village Houses and 36 Barns, Infrastructure and Landscaping	Rural Disaster Housing, Barns, Infrastructure, and Landscaping	8,412,254
8	Erzurum Province, Aşkale District (Gölören, Koşapınar, Topalçavuş Neighborhoods), 70 Single-story Village Houses, 76 Village Houses with Barns, and 5 Barns, Infrastructure and Landscaping	Rural Disaster Housing, Barns, Infrastructure, and Landscaping	8,631,579
9	Diyarbakır Province, Bağlar District, Karacadağ Region, 2nd Zone Phase 5, 1006 Houses with Infrastructure and Landscaping	Urban Disaster Housing, Infrastructure, and Landscaping	64,209,368
10	Adana Province, Sarıçam District, Göztepe Neighborhood, 1104 Houses with Infrastructure and Landscaping	Urban Disaster Housing, Infrastructure, and Landscaping	51,131,579

(Exchange rate: 38 TL/USD).

Initial data cleaning and validation procedures were conducted using Microsoft Excel. Projects containing incomplete or inconsistent records were identified and excluded. All remaining data entries were cross-verified against official records to ensure accuracy and completeness. Subsequently, the cleaned dataset was imported into IBM SPSS Statistics V26 for statistical analysis. The analytical methods employed included:

- Pearson correlation, to examine the relationship between the total project budget and the number of functional structures (H1).
- Independent samples *t*-tests, to determine whether total and unit costs differed significantly between mass housing and village housing projects (H2 and H4).

- Multiple linear regression analyses, to evaluate the individual impacts of each type of functional structure on total and per-unit project costs (H3 and H4).

Additionally, regression models were utilized to estimate budget figures for specific projects lacking precise financial data but having valid unit counts and functional structure indicators. These projected budgets were treated as estimates and thus excluded from the primary hypothesis testing, reported separately due to their potential implications for planning and policy development. Initially, all statistical analyses were conducted using Turkish lira (TL). However, to ensure consistency and comparability with international standards and throughout this study, all final results and statistical outcomes were converted into US dollars (USD) using a fixed exchange rate of 38 TL/USD.

4.2. Variable Classification and Data Coding

To facilitate rigorous hypothesis testing, each project was coded in the SPSS dataset according to two main dimensions. For clarity regarding the research design, Figure 1 below presents the conceptual framework, illustrating the primary project types, critical parameters, variables analyzed, analytical methods employed, and intended research outcomes.

(a) Project Type: Projects were classified into two distinct categories:

(i) Mass housing and (ii) village housing based on their physical characteristics and location. While mass housing projects refer to large-scale, typically urban developments consisting of multi-story residential buildings intended to provide housing units in urbanized areas, village housing projects represent smaller-scale, low-density developments located in rural or semi-rural settings, typically comprising single-family or small-unit dwellings spread across multiple villages.

Project titles, descriptions, and unit numbers primarily informed data classification categorization. In TOKI's project description, the number of mass housing and village houses is clearly defined as the scope of the project. Projects explicitly labeled as "village houses" or situated in sparsely populated regions were classified as village housing. Conversely, larger-scale projects explicitly described as "mass housing" or located within densely populated urban areas were categorized accordingly.

(b) Functional Structures: The second dimension involves the presence or absence of ancillary, non-residential facilities within each project. Mainly, qualitative content analysis was conducted on project documentation to identify these additional functional structures, specifically:

- Schools (coded as Has_school),
- Mosques (coded as Has_mosque),
- Commercial units or marketplaces (coded as Has_commercial),
- Barns or storage depots (coded as Has_barn).

These elements were recorded as separate binary variables, where 1 indicated presence and 0 indicated absence. Additionally, a composite variable—Functional Structure Count—was calculated by summing these binary indicators to reflect the project's total functional complexity.

The final analytical dataset included the following variables:

- Project ID and Province,
- Project Type (Mass Housing or Village Housing),
- Functional Structure Presence Indicators (School, Mosque, Commercial, Barn),
- Total Housing Units,
- Total Tendered Project Budget (Turkish Lira),
- Calculated Unit Cost (Cost_Per_House).

The research design and statistical methods applied in this study, as illustrated in Figure 2, provide rigorous tools for evaluating cost determinants in TOKI-managed post-disaster housing reconstruction projects.

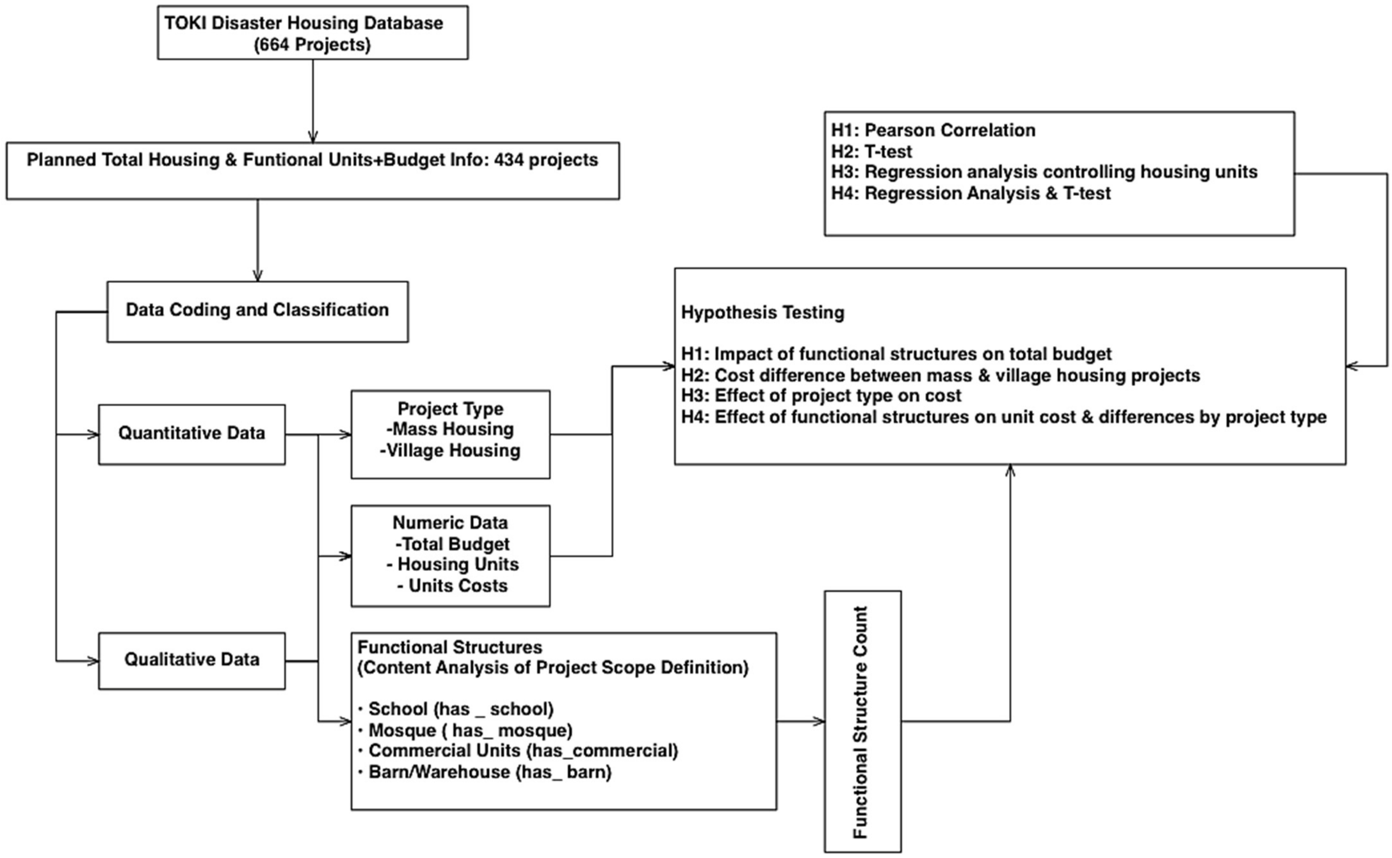

Figure 2. Research design and hypothesis development of the study.

4.3. Statistical Methods and Mathematical Formulations

The statistical methodologies and mathematical models outlined in this section were specifically selected to explore and quantify relationships among critical factors affecting the cost efficiency and project scope of TOKI's post-disaster housing reconstruction projects. Employing solid statistical techniques ensures the reliability of the study's findings, facilitating accurate cost estimations and providing a solid basis for strategic decision-making in future disaster housing initiatives. Accordingly, the differences in costs associated with project scale, the number and type of functional facilities, and the characteristics of housing developments were methodically examined using quantitative approaches.

- Pearson Correlation Analysis

Pearson correlation was utilized in this study to determine the linear association between the total project costs and the quantity of functional structures included within each housing project. This analytical approach effectively captures the direct linear relationships, thus aiding in understanding how varying levels of project complexity, expressed through the inclusion of different facilities, impact overall expenditure [30].

$$r = \frac{\sum(x_i - \overline{x})(-\overline{y})}{\sqrt{\sum(x_i - \overline{x})^{2\sum(y_i - \overline{y})^2}}}$$

- ○ r represents the correlation coefficient,
- ○ x_i, y_i are observed values,

- $\overline{x}, \overline{y}$ denote the sample means.

In this study, the Pearson correlation coefficient (r) specifically quantifies the relationship between the dependent variable (Y), representing the total cost of TOKI's post-disaster housing projects, and the independent variable (X), denoting the number of integrated functional structures, providing valuable insights into cost efficiency associated with project complexity.

- Independent Samples t-test

To statistically compare cost differences between rural village housing and urban mass housing projects, an independent samples t-test was conducted. This method provides an objective measure to evaluate whether the difference in mean costs between these two project types is statistically significant, thereby clarifying the role of project typology in influencing total and per-unit costs [31–33].

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

- $\overline{x_1}, \overline{x_2}$ represent sample means,
- s_1^2, s_2^2 represent sample variances,
- n_1, n_2 indicate sample sizes of each group.

In this study, the independent samples t-test compares the mean total costs between two distinct project types mass housing and village housing with $\overline{x_1}, \overline{x_2}$ denoting the respective sample means of total costs, s_1^2, s_2^2 representing their variances, and n_1, n_2 indicating the number of projects included in each category, enabling an objective evaluation of cost differences related to project scale and typology.

- Multiple Linear Regression Analysis

Multiple linear regression analysis was employed to individually quantify the impact of specific functional structures such as schools, mosques, commercial units, and barns on per-unit construction costs. This approach allows for the clear delineation of each independent variable's effect on cost outcomes, thus facilitating a nuanced and precise evaluation of functional structure influences [34].

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n +$$

- y is the dependent variable (unit cost), represent sample are independent variables,
- β_0 is the intercept and β_1, β_2, …, β_n are regression coefficients,
- ε epsilon represents the error term.

In this study, Y represents the dependent variable, specifically defined as the unit construction cost of TOKI's post-disaster housing projects; the independent variables include the presence of functional structures such as schools, mosques, commercial units, and barns. The term β_0 denotes the intercept, while β_1, β_2, …, β_n are the regression coefficients quantifying the individual impact of each functional structure and ε symbolizes the error term capturing unexplained variance within the regression model.

5. Results

The results are organized and presented under five thematic sections as follows:

- General Project and Housing Numbers by Province,
- Impact of Functional Structures on Total Project Budget,
- Comparison of Total Costs Between Mass Housing and Village Housing Projects,

- Impact of Functional Structures on Per-Unit Costs,
- Impact of Functional Structures on Unit Costs.

5.1. General Project and Housing Numbers by Province

Figure 3 illustrates the extensive distribution of total functional units allocated per province within post-disaster housing projects, as reported by TOKI [30]. These functional structures include schools, mosques, commercial units, and warehouses, some of which also serve as barns for livestock storage. According to the agency's updated disaster housing database, a substantial total of 664 projects are planned across 40 provinces, aiming to deliver an impressive 342,354 housing units overall.

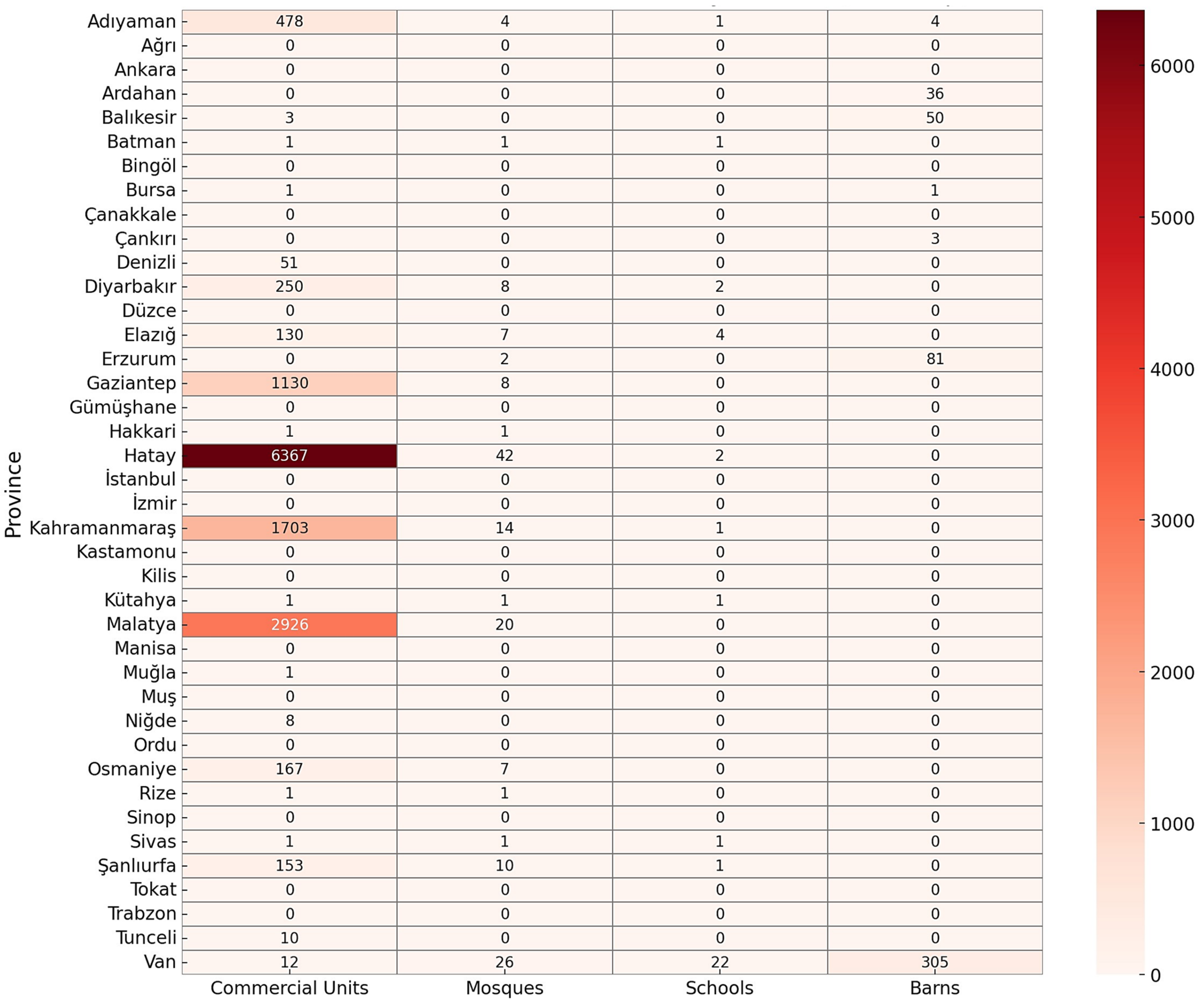

Figure 3. Distribution of functional structures by province.

The highest numbers of commercial units were observed in Hatay (6367 units) and Malatya (2926 units), where large-scale commercial developments, often in the form of bazaars and shopfronts, were constructed as part of urban renewal initiatives following the 6 February 2023 earthquake.

The data show regional variation in TOKI's investment priorities. In terms of religious and educational facilities, the data indicate that a significant number of mosques were built in Hatay (42) and Malatya (27), suggesting a prioritization of religious infrastructure.

Although fewer in number, educational buildings were still noteworthy, with Van hosting 22 schools and Elazığ hosting 4, reflecting TOKI's adaptability and responsiveness to local needs. Moreover, the data reveal a spatial focus on rural infrastructure in certain provinces, consistent with agricultural livelihood needs. Van accounted for 305 barns, followed by Erzurum (81), Ardahan (36), and Balıkesir (50), indicating TOKI's commitment to addressing diverse community needs. In contrast, many other provinces included minimal or no such facilities, with a stronger emphasis on basic housing provision rather than broader community infrastructure.

Notably, the provinces most severely affected by the 2023 earthquake—Hatay, Malatya, and Kahramanmaraş—recorded the highest number of projects and residential units. For instance, Hatay alone accounted for 180 projects, a significant number, encompassing more than 119,971 housing units. By comparison, provinces impacted by less severe disasters or those previously receiving aid typically initiated only one to three projects. Figures 4 and 5 provide a comprehensive alphabetical listing of all provinces, along with their corresponding project counts and housing unit totals.

5.2. Impact of Functional Structures on Total Project Budget

The number of projects illustrated in Figure 5 indicates the total number of housing units constructed along with other functional structures (such as schools, mosques, commercial units, and barns/storage facilities) for each province. Provinces undertaking a higher number of projects generally have more extensive and varied ancillary facilities, particularly in areas heavily impacted by major disasters. For instance, Hatay, one of the provinces most severely affected by the February 2023 earthquake, hosts numerous supplementary facilities, including 42 mosques and thousands of commercial units. Similarly, Malatya and Kahramanmaraş possess substantial supporting infrastructure, underscoring extensive reconstruction requirements. Conversely, provinces like Bingöl, Çankırı, and Muğla, characterized by fewer or smaller projects, primarily focus on basic housing without significant supplementary infrastructure.

Based on the observations described above, this study specifically tested Hypothesis 1 (H1), which proposes a positive correlation between the number of functional structures included in a project and the project's total cost. To examine this hypothesis, Pearson correlation analysis was conducted using the full dataset comprising 434 TOKI projects, including 418 mass housing and 16 village housing projects.

H1 (Functional Scope): "The number of functional structures included in a housing project has a positive correlation with the total budget of the project."

Further illustrating this relationship, Figure 6 contains a boxplot which illustrates the distribution of total project costs categorized by the number of functional structures included in each project. Categories labeled 0, 1, 2, and 3 indicate projects without functional buildings (residential units only), projects containing one functional building type (such as a school or mosque), projects with two types of functional structures, and projects with three or more types of functional structures, respectively. Outliers and extreme values are marked distinctly in the boxplot, where circular markers (°) represent moderate outliers and the numbers next to these circles correspond directly to the case numbers (project ID numbers) in the dataset. These numbers do not represent project counts or unit quantities but rather serve as identifiers for individual projects flagged as statistical outliers. And asterisks (*) denote more significant extreme outliers, each accompanied by a case number identifying the specific project. These markers indicate projects whose costs notably deviate from the central tendency of their respective groups. In addition, Pearson's correlation confirms a statistically significant negative association between the Total Project Cost and the Functional Structure Count ($r = -0.209$, $n = 434$, $p < 0.001$).

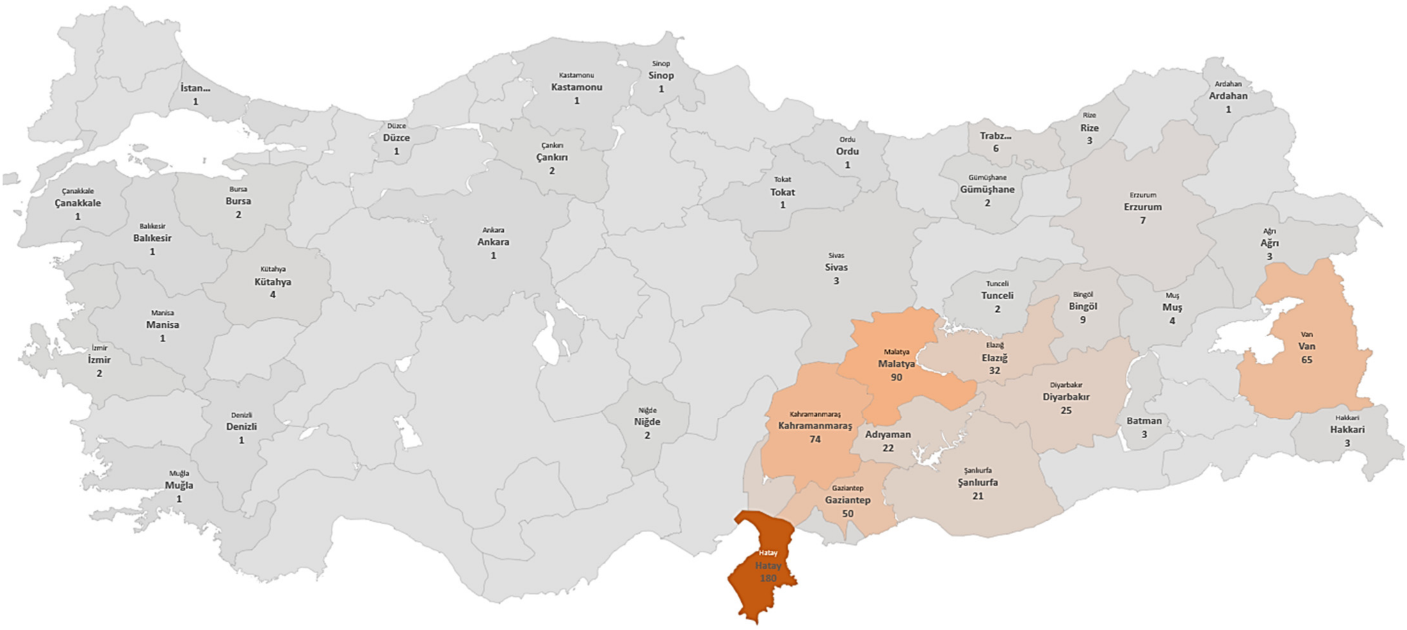

Figure 4. Number of Disaster Projects by Province in Türkiye. ■ **(>100)** Hatay (180); ■ **(50–99)** Malatya (90), Van (65), Kahramanmaraş (74), Gaziantep (50); ■ **(20–49)** Elazığ (32), Şanlıurfa (21), Adıyaman (22), Diyarbakır (25); ■ **(1–19)** İstanbul (1), Çanakkale (1), İzmir (2), Muğla (1), Manisa (1), Denizli (1), Bursa (2), Balıkesir (1), Kütahya (4), Düzce (1), Ankara (1), Kastamonu (1), Sinop (1), Tokat (1), Sivas (3), Trabzon (2), Gümüşhane (2), Erzurum (7), Erzincan (3), Tunceli (2), Bingöl (9), Muş (4), Bitlis (4), Batman (3), Şırnak (3), Hakkari (3), Ağrı (3), Ardahan (3), Ordu (1), Niğde (2), Çankırı (2).

Figure 5. Number of Disaster Houses (Mass Housing + Village Houses) by Province in Türkiye. ■ **(>100,000)** Hatay (119,971); ■ **(50,000–99,999)** Malatya (55,198); ■ **(20,000–49,999)** Gaziantep (23,795), Kahramanmaraş (41,783); ■ **(1–19,999)** Adıyaman (7647), Ağrı (804), Ankara (726), Ardahan (68), Balıkesir (39), Batman (1202), Bingöl (1973), Bursa (102), Çanakkale (40), Çankırı (107), Denizli (408), Diyarbakır (14,847), Düzce (120), Elazığ (11,180), Erzurum (857), Gümüşhane (292), Hakkari (344), İstanbul (114), İzmir (252), Kastamonu (148), Kilis (1854), Kütahya (1196), Manisa (80), Muğla (24), Muş (144), Niğde (425), Ordu (64), Osmaniye (8098), Rize (640), Sinop (74), Sivas (164), Şanlıurfa (11,488), Tokat (32), Trabzon (706), Tunceli (576), Van (17,708).

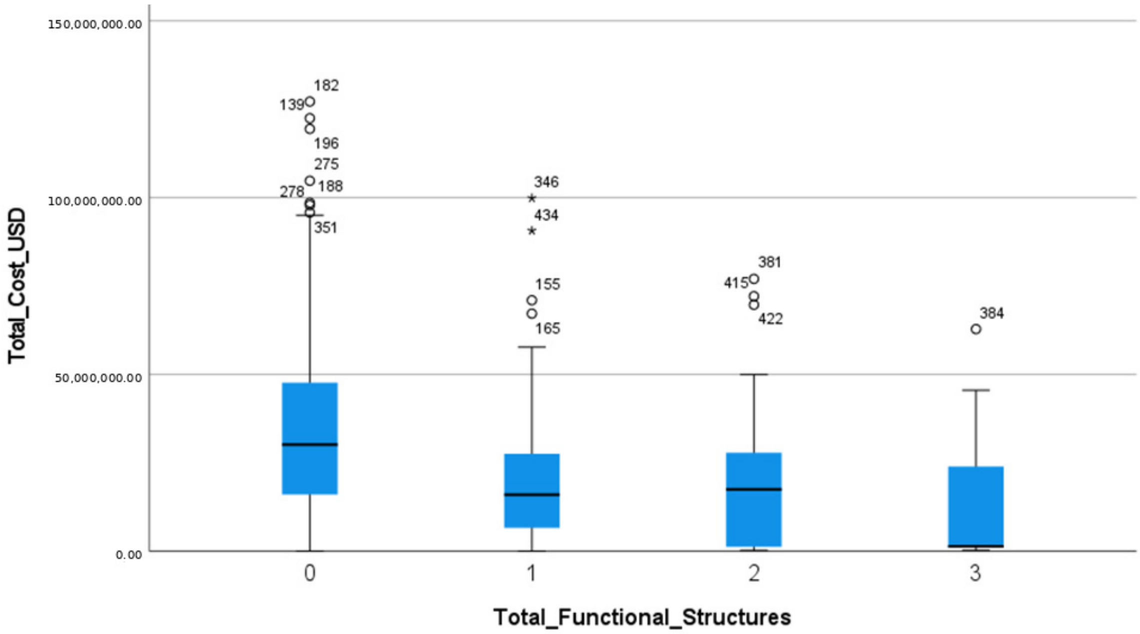

Figure 6. Impact of functional structures on total project budget.

However, the unexpected finding indicates that adding facilities like schools, mosques, commercial units, and barns to a project helps achieve economies of scale through cost distribution across multiple units which reduces total expenses. Projects that include multiple ancillary structures tend to be larger in scale, which allows for cost distribution across more units, thus producing lower total cost results than expected. The USD-based analysis fails to support Hypothesis 1 (H1) because it shows a negative correlation between structure numbers and project costs. The analysis shows that projects containing additional functional structures result in substantially reduced total project budgets. The unexpected negative correlation exists because large-scale projects implement efficient resource management practices which include standardized procurement processes together with reduced transaction costs and streamlined project administration.

5.3. Comparison of Total Costs Between Mass Housing and Village Housing Projects

An independent-samples *t*-test was used to test Hypothesis 2 (H2) that mass housing projects have higher total construction costs than village housing projects because of their larger scale.

- "H2 (Project Type—Total Cost): Mass housing projects are larger in scale and therefore have significantly higher total budgets than village housing projects."

It is important to distinguish between total project budgets which are significantly higher in mass housing projects because of their larger scale and per-unit housing costs where statistical analyses revealed no significant differences.

Before conducting the *t*-test, Levene's test was used to check the equality of variance assumption. The result showed that there was a significant difference in variances ($F = 12.80$, $p < 0.001$), thus violating the homogeneity of variance assumption required for a standard independent samples *t*-test. Therefore, Welch's *t*-test [21] which is designed to handle unequal variances, was used to analyze the difference in total project costs.

Hence, Welch's *t*-test is used to determine whether the means of two independent groups are significantly different without the need for equal variances between groups [21]. This makes it particularly suitable in cases where variance inequality is evident.

The analysis results shown in Table 2 indicate a highly significant difference between the two project types, with mass housing projects having substantially greater total budgets (mean ≈ USD 31.47 million) compared to village housing projects (mean ≈ USD 5.38 million). The adjusted degrees of freedom for Welch's test (df = 32.75) are considerably lower than the overall sample size (N = 434, df = 432), reflecting the correction applied due to unequal variances and the much smaller sample size in the village housing category.

Table 2. Summary statistics and comparison for total cost by project type.

Project Type	**N**	**Mean (USD)**	**Std. Dev. (USD)**	**Std. Error**
Mass Housing	418	31,470,567	24,566,481	1,201,586
Village House	16	5,382,293	6,910,280	1,727,570
Test	**Value**			
Levene's F	12.80 ($p < 0.001$)			
t-value	t(32.75) = 12.397, $p < 0.001$			
df (adjusted)	32.75			
p-value	<0.001			
Cohen's d	1.08			

(Exchange rate: 38 TL/USD).

Practically, these findings substantially support Hypothesis 2, underscoring that mass housing projects characterized by larger construction scales and more extensive infrastructural requirements indeed have significantly higher total project budgets compared to smaller, less densely developed village housing projects. The total budgets between the two project types were different but per-unit housing costs were not significantly different, which highlights the need to distinguish between total and per-unit cost metrics, Figure 7.

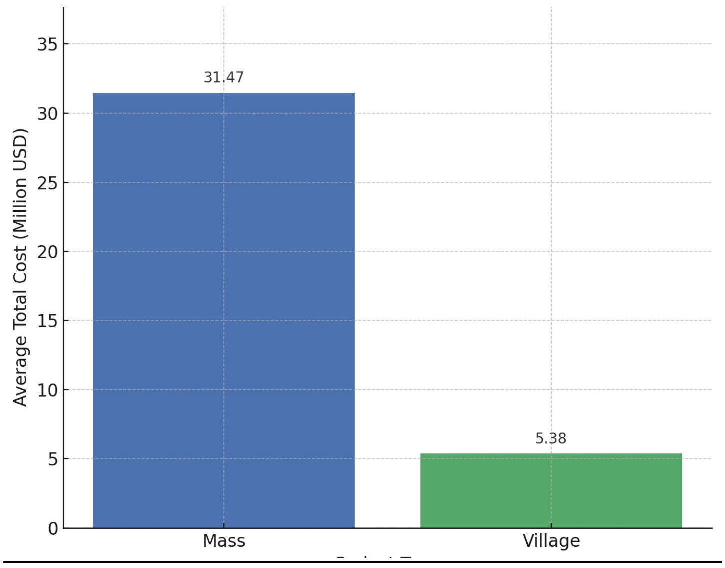

Figure 7. Comparison of total costs between mass housing and village housing project.

5.4. Impact of Functional Structures on Per-Unit Costs

H3 was investigated using multiple linear regression analysis to determine the effect of certain functional structures on per-unit housing costs.

The overall regression model was statistically significant (F(4, 429) = 13.73, $p < 0.001$), which means that these functional structures have a significant impact on housing unit costs. Moreover, the calculated R^2 value of 0.114 means that these structures explain about 11.4% of the variation in unit costs. According to established research [33], an R^2 below 0.25 means that the predictive power is low and other variables such as geographic factors, inflation, and market conditions should be included in future studies to increase the explanatory power.

Key results from the regression analysis in Table 3 are shown below.

Table 3. Regression analysis for per-unit cost and functional structures.

Variable	B Coefficient (USD)	Std. Error	Beta	t-Value	*p*-Value
Intercept	53,788	1346	—	39.94	<0.001
School	−34,543	7197	−0.245	−4.80	<0.001
Mosque	−10,071	4629	−0.126	−2.18	0.030
Commercial	+3798	3729	0.053	1.02	0.309
Barn	+29,361	10,372	0.129	2.83	0.005

Model fit: $R^2 = 0.114$ Adjusted $R^2 = 0.105$ F(4, 429) = 13.73, $p < 0.001$, Exchange rate: 38 TL/USD. Note: The degrees of freedom notation "F(4, 429)" in the multiple regression analysis is derived from the number of predictor variables and the total number of cases analyzed. Specifically, "4" represents the count of independent predictor variables used in the model (in this case school, mosque, commercial unit, and barn) while "429" is calculated by subtracting the number of predictors plus one (representing the intercept) from the total number of observations. Therefore, with 434 total cases, the degree of freedom for the residual error term becomes 434 − 4 (predictors) − 1 (intercept) = 429. This explains the notation "F(4, 429)", which denotes the variance ratio test used to determine the statistical significance of the overall regression model.

- School presence (cost decrease): Projects that include at least one school have lower per-unit costs. More specifically, the inclusion of a school leads to a cost reduction of USD 34,543 per housing unit (B = −34,543 USD, $p < 0.001$, $\beta = -0.245$). This moderate negative effect means that schools are usually included in larger projects that benefit from economies of scale.
- Mosque presence (cost decrease): As with schools, the presence of mosques also results in lower unit costs by USD 10,071 per housing unit (B = −10,071 USD, $p = 0.030$, $\beta = -0.126$), which is a significant cost efficiency due to economies of scale or external funding.
- Commercial units (no significant effect): Commercial units, such as shops, increase per-unit costs, but the effect is not significant (B = +3798 USD, $\beta = +0.053$, $p = 0.309$). This means that the cost effects of commercial facilities are context-dependent and not always offset or influence per-unit housing costs significantly.
- Barn presence (cost increase): Projects that include barns or storage depots cost more per unit, with an increase of USD 29,361 per housing unit (B = +29,361 USD, $p = 0.005$, $\beta = +0.129$). This significant positive effect means that specialized rural facilities, such as barns, add costs because they do not offer much scale efficiency.

In summary, the regression analysis confirms Hypothesis 3, which indicates that different functional structures have different effects on the housing unit costs. Schools and mosques are effective in reducing the per-unit cost through economies of scale, barns are effective in increasing per-unit cost, and commercial facilities have no effect. The regression model is mathematically represented by

$$\text{Unit Cost} = 53{,}788 - 34{,}543\ (\text{School}) - 10{,}071\ (\text{Mosque}) + 3798\ (\text{Commercial}) + 29{,}361\ (\text{Barn}) + \varepsilon.$$

Pearson correlation analysis further supports these findings, revealing a significant negative correlation between the number of functional structures and total project costs (r = −0.209, $p < 0.001$), emphasizing the cost-efficiency advantages of scale in multi-facility projects. The regression results (with coefficients in USD, Figure 8) are presented below.

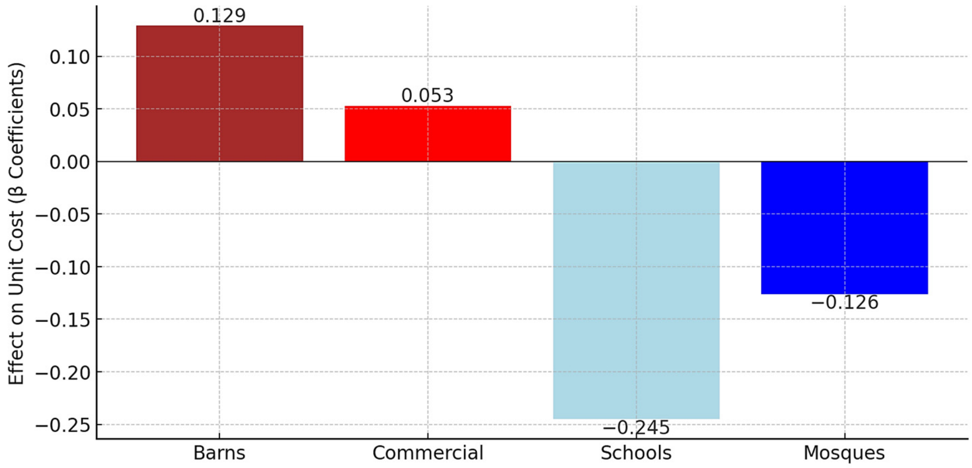

Figure 8. Impact of functional structures on unit costs.

5.5. Impact of Functional Structures on Unit Costs

Finally, Hypothesis 4 (H4) proposed that village housing projects would have higher per-unit costs compared to mass housing projects due to lower density and logistical challenges.

- "H4 (Project Type—Unit Cost): Mass housing projects differ systematically from village housing projects in per-unit costs, but this difference is influenced primarily by the inclusion of specific functional structures (e.g., barns) rather than by project type alone."

An independent-samples *t*-test was conducted to compare the per-unit costs of the two housing project types shown in Table 4. Again, the assumption of equal variances was first examined through Levene's test and found to be violated (F = 37.41, $p < 0.001$). Therefore, Welch's adjusted *t*-test was again employed to ensure accurate statistical inference. However, Welch's *t*-test results indicate no statistically significant difference in per-unit costs between mass housing (M = USD 52,360, SD = USD 24,920, n = 418) and village housing projects (M = USD 49,810, SD = USD 55,480, n = 16) (t(15.232) = 0.183, $p = 0.857$).

The notably low degrees of freedom (df = 15.232) result from the small sample size of village housing projects combined with substantial variance differences between the two groups. Indeed, Welch's method statistically decreases degrees of freedom when variances are unequal, especially evident here with one group significantly smaller and displaying greater variance [21].

This lack of significant difference implies that the anticipated cost disadvantage for village housing projects due to dispersed rural layouts is not evident in practice. Hence, Hypothesis 4 (H4) receives only "partial support" within the context of TOKI-managed reconstruction initiatives. The observed unit cost similarities indicate that cost differences between mass and village housing projects are influenced less by the urban–rural dichotomy and more by specific functional structures, notably barns, which highlight effective cost management practices that counterbalance potential logistical challenges inherent in rural construction environments.

Table 4. Per-Unit Cost by Project Type.

Project Type	N	Mean ($)	Std. Dev. ($)	Std. Error
Mass	418	52,358	24,915	121.863
Village	16	49,812	55,485	13,871
Test	**Value**			
Levene's F	41.301 ($p < 0.001$)			
t-value	0.183			
df (adjusted)	15.232			
p-value	0.857			
Cohen's d	0.096 (negligible effect)			

(Exchange rate: 38 TL/USD).

6. Discussion

The main goal of this research was to determine the impact of project types and functional structures on the costs of post-disaster permanent housing projects managed by TOKI in Türkiye. The quantitative analysis included 434 TOKI-managed disaster housing projects, which contained approximately 242,415 housing units, including about 2130 village houses specifically designed for rural settlements. The total investment for these projects was approximately USD 1.32 billion, based on a fixed exchange rate of 38 Turkish Liras per US dollar. These figures reflect the scale and extent of financial investment involved in post-disaster reconstruction projects in Türkiye, including both large urban mass housing developments and specific rural projects within the overall recovery efforts.

Contrary to initial expectations, the results revealed a statistically significant negative correlation between project budgets and the number of functional structures within projects ($r = -0.209$, $p < 0.001$). Functional structures, defined as facilities not directly associated with residential housing (e.g., educational institutions, places of worship, commercial units, agricultural buildings), were initially expected to increase overall project costs in line with assumptions in previous literature [22]. However, the results suggest that the inclusion of these structures actually improved resource management efficiency, potentially due to streamlined procurement processes, reduced transaction costs, and standardized project management practices, as highlighted in studies of disaster housing reconstruction strategies [24]. Thus, hypothesis H1, predicting an increase in costs due to the inclusion of functional structures, was not supported.

Additionally, total costs showed significant differences between mass housing and village housing projects. Mass housing projects incurred total expenses of approximately USD 3.16 billion, whereas village housing projects accounted for roughly USD 538 million. This substantial discrepancy supports hypothesis H2, indicating that the overall cost structure is primarily driven by economies of scale associated with larger, densely populated mass housing projects, consistent with observations in related international case studies [26].

However, statistical analysis of per-unit housing expenses showed no meaningful distinction between mass housing and village housing projects ($t(15.232) = 0.183$, $p = 0.857$). The study's results did not fully support the initial hypothesis H4 which stated that village housing projects would naturally have higher per-unit expenses. The research results showed that project size determines total budgets which provides policymakers with practical evidence for strategic resource allocation.

Furthermore, the analysis of single functional structures in relation to per-unit costs generated more detailed information. The regression analysis revealed a positive significant relationship between barn structures and unit costs ($\beta = 0.129$, $p = 0.005$) because agricultural structures need more materials and logistical resources. Conversely, educational facilities demonstrated the most considerable negative effect on unit costs (β = −0.245, $p < 0.001$), supporting the conclusion that integrating schools into housing projects leverages economies of scale and standardized construction processes, significantly reducing per-unit costs. Religious structures, such as mosques, also contributed to cost reductions (β = −0.126, $p = 0.030$). The inclusion of commercial facilities did not yield statistically significant effects on per-unit costs (β = 0.053, $p = 0.309$), indicating that their financial implications are project-specific and context-dependent.

Overall, the unit cost comparison showed no meaningful differences between mass housing and village housing projects, which contradicted the initial expectations of higher rural construction costs because of logistical challenges and lower construction density. Thus, hypothesis H4 was only partially supported, suggesting cost structures are nuanced and less predictable based solely on regional or housing typology considerations.

Consequently, to enhance the cost-effectiveness and quality of housing provisions, it is recommended that strategic integration of functional structures be systematically incorporated into project planning. Adopting well-managed, coordinated approaches that extend beyond residential construction to include educational, religious, and rural infrastructure proves economically viable and socially beneficial, providing a reliable foundation for sustainable community development in post-disaster recovery scenarios [23,24].

7. Conclusions

The study used quantitative analysis approaches to offer a detailed assessment of the effect of project scope, functional structures, and project type on the costs of post-disaster housing reconstruction in Türkiye. It systematically employed Pearson correlation, independent samples *t*-tests, and multiple regression analyses to identify key cost determinants in post-disaster housing reconstruction projects.

A notable finding of this study is the negative correlation identified between the number of functional structures and total project costs (r = −0.209, $p < 0.001$), which contrasts with initial expectations. This result contradicts common assumptions suggesting that additional structures typically increase project costs. It implies that incorporating various community-based facilities within one project can lead to cost-effectiveness by reducing project expenses.

Additionally, the mass housing projects were found to have significantly higher total costs, averaging at USD 31.47 million as opposed to village housing projects which had average costs of USD 5.38 million, but no significant difference was found in per-unit construction costs. This indicates that total project costs are predominantly influenced by project scale rather than by project type alone.

Further regression analysis provided detailed insights into the individual impacts of different functional structures examined in this study. The presence of barns as special structures increased the cost of constructing each unit by approximately USD 29,361 (β = 0.129, $p = 0.005$). The presence of schools and mosques together led to reduction in per-unit costs by USD 34,543 (β = −0.245, $p < 0.001$) and USD 10,071 (β = −0.126, $p = 0.030$) because of standardized designs which enabled cost reduction through economies of scale. The study showed that commercial facilities did not have any statistically important effect on the costs (β = 0.053, $p = 0.309$) because project-specific financial factors were most significant.

In total, this study focused on 434 TOKI-managed disaster housing projects which had 242,415 housing units and 2130 rural village houses. The total financial investment was USD 1.32 billion, which shows that Türkiye is very much committed to post-disaster reconstruction efforts. The unit costs were determined at the project level in this study by using the total project expenses divided by the total number of housing units since different functional structures were found in different projects.

Based on these comprehensive findings, this study proposes recommendations for policymakers, planners, and project managers aimed at improving cost efficiency in post-disaster housing reconstruction. The following recommendations are useful guidelines to enhance cost efficiency in post-disaster housing reconstruction:

1. Promote the active encouragement of standardized communal facilities such as schools and mosques in housing projects which provide both social and cost benefits;
2. Control the rural projects with specialized structures like barns by appropriate budget adjustments or pre-design phase optimization to reduce per-unit costs;
3. Promote standardization in design in order to enhance operational efficiency, reduce construction time, minimize material waste, and achieve high-quality outcomes consistently.

In conclusion, this study contributes to the existing literature by quantitatively exploring cost determinants in Türkiye's post-disaster housing reconstruction, providing evidence-based insights useful for recovery planning and policy formulation. However, the study's analysis is limited by regional data variability and TOKI's centralized project management practices. Additionally, the fixed exchange rate used in this analysis might not accurately capture actual market conditions such as inflation or temporal cost changes. Future research is therefore encouraged to use more sophisticated models and include other influencing factors like regional cost differences, inflation rates, and market trends. This will improve predictive accuracy, resource efficiency, resilience, and effectiveness in future global post-disaster reconstruction interventions.

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Data Availability Statement: Project data used in this study were obtained from open-access records published on TOKI's official website (https://www.toki.gov.tr/) accessed on 15 January 2025.

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Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BBB	Build Back Better
MAP	Moduli Abitativi Provvisori
GEJE	Great East Japan Earthquake
GDP	Gross Domestic Product
TOKI	The Mass Housing Administration of Türkiye
TUIK	The Turkish Statistical Institute
SPSS	Statistical Package for the Social Sciences

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