# Territorial Dynamics of Housing: Structural Patterns, Market Accessibility, and Public Policy Implications

João Lourenço Marques(✉), João Canas, and Monique Borges

Department of Social, Political and Territorial Sciences, GOVCOPP, University of Aveiro, Campus Universitário de Santiago, Aveiro, Portugal
jjmarques@ua.pt

**Abstract.** This study presents a spatially disaggregated analysis of housing dynamics in Portugal. Using a quantitative and spatial approach, the research integrates census data, administrative records, and public policy documentation to examine key housing indicators across municipalities. Synthetic indicators were constructed to capture multidimensional aspects of housing supply and demand, affordability, and market dynamics to identify territorial patterns and disparities. The findings reveal marked spatial heterogeneity: beyond the expected pressures in metropolitan and coastal municipalities, certain inland district capitals display unexpectedly high levels of housing demand and affordability tensions, while some peripheral municipalities with limited market activity exhibit misalignments between income and housing costs. The findings underscore the coexistence of structural imbalances and socio-territorial inequalities, highlighting the need for geographically targeted housing policies and more effective implementation of public programs.

**Keyword:** Housing market dynamics · Housing affordability · Territorial inequalities · Spatial multivariate analysis

## 1 Introduction

The 2008 global financial crisis profoundly impacted housing provision and access, exposing structural supply, affordability, and planning weaknesses. In response, Portugal launched the National Housing Strategy (*Estratégia Nacional de Habitação*) in 2015, aiming to reorient housing policies through three foundational pillars: promoting urban rehabilitation by simplifying building restoration processes, revitalizing the rental market, and improving housing quality. This strategy also incorporated a strong social dimension, emphasizing the inclusion and protection of vulnerable groups while acknowledging emerging demographic and territorial challenges.

Building on this foundation, the government introduced the New Generation of Housing Policies (*Nova Geração de Políticas de Habitação* – NGPH) in 2018 [1]. This new framework emerged from the findings of the National Housing Needs Survey (*Levantamento Nacional das Necessidades de Realojamento Habitacional*) [2], which identified

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tens of thousands of families living in substandard conditions across the country, even though the recent strategic documents made by the municipalities – Municipal Housing Plans (*Cartas Municipais de Habitação*) – have identified a lot more families in need. The NGPH expanded the scope of housing policies, integrating and relating concepts of "housing" and "habitat", turning the focus from the "house" (object) to the "person" or the access to housing (objective), while extending support to a broader range of beneficiaries through programs such as First Right, a housing support program for vulnerable households (*1º Direito*), a rental subsidy specifically designed for people up to 35 years old (*Porta 65 Jovem*), and a building rehabilitation program to increase rental supply (*Reabilitar para Arrendar*).

In 2019, the Housing Framework Law (*Lei de Bases da Habitação*) was enacted, formally establishing housing as a fundamental right and defining the State's responsibilities in ensuring its provision. More recently, significant legislative developments—namely the More Housing (*Mais Habitação)*package (- measures aimed at improving housing affordability, increasing supply, and regulating the rental market in Portugal - Law No. 56/2023) and the National Housing Program 2022–2026 (Law No. 2/2024)—have outlined concrete policy instruments and objectives, from increasing affordable housing stock to implementing fiscal incentives for housing rehabilitation and access. The most recent policy initiative, Building Portugal: A New Housing Strategy (*Construir Portugal: Nova Estratégia para a Habitação*)— the most recent national housing policy framework introduced in 2024, aimed at expanding access, promoting affordability, and incentivizing homeownership among younger generations. It includes tax exemptions (IMT and IS) for home purchases by individuals under 35, aiming to improve access for younger generations.

While the constitutional right to housing has been recognized since 1976, the realization of this right has remained uneven. Despite the proliferation of programs and legal frameworks, various challenges persist: fragmentation across policy instruments, territorial implementation disparities, and persistent affordability and segregation issues. The coexistence of tax incentives for foreign investors, short-term rental legislation, and programs aimed at vulnerable populations have often produced contradictory outcomes, as well as housing speculation, over-reliance on tourism-driven demand, and a mismatch between public policy goals and market behavior have contributed to rising tensions in the housing sector [3–6].

The housing crisis in Portugal (as well as housing public policies) has been a matter of study throughout the years, especially after the subprime crisis and its repercussions. While some studies (for the Portuguese context) try to approach the problem more qualitatively by doing a critical analysis and exploring their contradictions to the various housing policies and programs [7–9], others try to measure housing needs and affordability issues using different quantitative methods and approaches. For instance, while some try to measure the reality of the problem using survey methods [10, 11], others have significantly different approaches, mainly to assess housing affordability [12], with some even using k-means clustering and linear regressions to find similar affordability patterns in mainland Portugal [13, 14].

This paper presents a comprehensive and spatially disaggregated analysis of the housing situation in Portugal. It seeks to characterize the structure and condition of

the housing stock, evaluate the territorial distribution of housing needs, while trying to understand the influence of new housing demands. With this, we try to answer three research questions (RQ):

RQ1: How has the housing stock developed in the last decade throughout the territory concerning household variation?

RQ2: How does affordability change regarding the relation between housing prices and household income, as well as the Price Consumer Index?

RQ3: How do the "new demand patterns" influence (or are influenced by) the previous two questions?

Through this approach, the study contributes to a deeper understanding of the socio-territorial inequalities that shape the contemporary Portuguese housing landscape, using a differentiated approach in the Portuguese context. However, the approach used is being widely applied on other territorial contexts, especially related to housing markets, where Principal Component Factor Analysis (PCFA) is used as a pre-process for clustering [15–17].

## 2 Methodology

The study adopted a quantitative and spatial analysis approach, focusing on identifying territorial patterns through statistical analysis of housing stock characteristics, demographic and family structure trends, and key housing market indicators such as rental prices and ownership costs. The analysis relied primarily on official datasets and administrative records to ensure accuracy and consistency. The core sources included:

- National Census data from the National Statistics Institute (INE)
- Reports from the Institute for Housing and Urban Rehabilitation (IHRU) and the National Statistics Institute (INE)
- Policy documents and program data from the Housing Portal, Centre for Planning and Policy Evaluation (PlanAPP), and Tourism of Portugal

The methodological framework of this study involved integrating and harmonizing multiple datasets to enable a spatially detailed analysis of housing dynamics across Portuguese municipalities. The first phase of data processing focused on aggregating census data from 2011 and 2021, initially sourced at the sub-municipal level (BGRI). From the 2011 census, only variables directly relevant to the housing dimensions specifically the number of classic family dwellings and private households—were retained. The 2021 census dataset, comprising approximately 1.99 million entries, was fully incorporated. Following a process of variable selection, filtering, and spatial aggregation to the municipal scale (NUTS IV), a dataset of 1,848 valid spatial units was obtained. In parallel, a second dataset was constructed using 2021 housing market indicators published by the National Statistics Institute (INE), including variables such as rental prices, purchase prices, and income levels. This dataset covered 2,464 territorial units. Subsequently, both datasets were merged using a common geographical identifier. The resulting integrated dataset, comprising 5,236 aggregated records, provided the empirical foundation for developing composite indicators and spatial typologies explored in the subsequent analytical stages.

Two main quantitative methods were applied to achieve these territorial patterns: PCFA – used to develop synthetic indicators that try to demonstrate three different housing dynamics (Housing Supply vs. Demand; Affordability; New Demand Patterns) and K-Means Clustering, used to aggregate the results given by the first method (pre-process), thus representing municipalities with similar characteristics that can describe distinct territorial patterns.

Key variables analyzed included housing typologies, occupancy status, vacancy rates, age of the housing stock, rental regimes, and construction trends. Municipalities (NUTS IV) were selected as the territorial units of analysis, providing sufficient spatial detail to capture local housing dynamics while maintaining coherence with national-level patterns. In addition, synthetic indicators—such as affordability, market dynamics, and housing demand profiles—were developed to facilitate interpretation. Most of the data utilized in this study is publicly available in open-source formats such as.csv,.xlsx, and geopackage (.gpkg) files. Data processing and analysis were conducted using Python, employing libraries for data manipulation, visualization, and spatial analysis. Table 1 summarizes the merged dataset.

**Table 1.** Housing and socioeconomic variables.

| Attribute | Data type | mean | max | min | std |
|---|---|---|---|---|---|
| Housing buying price (€/m$^2$) | Float | 822.2 | 3412.0 | 191.8 | 487.5 |
| Municipal property tax (€) | Float | 4876.0 | 124252.0 | 16.0 | 10147.9 |
| Property tax associated with buying a house (€) | Float | 4444.2 | Float | 0.0 | 17793.3 |
| Average building age (years) | Float | 46.7 | 67.2 | 33.0 | 6.1 |
| Number of houses sold (units) | Integer | 1423.2 | 23162.0 | 0.0 | 2724.6 |
| Ratio between the number of families and the number of dwellings | Float | 1.8 | 3.2 | 1.1 | 0.4 |
| Ratio between empty/vacated dwellings and the total of existing dwellings | Float | 0.1 | 0.3 | 0.1 | 0.0 |
| Average dwelling size (m$^2$) | Float | 122.7 | 155.4 | 82.4 | 11.8 |
| Housing rental price (€/m$^2$) | Float | 4.4 | 11.2 | 2.0 | 1.7 |
| Average income post taxes and deductions (€) | Float | 1166.8 | 1945.6 | 914.0 | 161.9 |
| Consumer Price Index | Float | 82.4 | 186.3 | 60.7 | 15.7 |
| Number of rental contracts (units) | Integer | 447.9 | 9548.0 | 33.0 | 898.8 |
| Number of families (units) | Integer | 13471.1 | 242571.0 | 155.0 | 23362.2 |
| Number of classical (conventional) dwellings | Integer | 19394.4 | 242571.0 | 205.0 | 29345.4 |
| Dwelling variation between 2011 and 2021 | Float | 0.0 | 0.1 | -0.1 | 0.0 |
| Families variation between 2011 and 2021 | Float | 0.0 | 0.2 | -0.3 | 0.1 |

## 3 Results

This section presents the main results, structured into four interconnected analytical components. The first component examines the relationship between housing supply and demand by quantitatively comparing housing stock availability with the number of resident families. The second component addresses overall housing affordability without distinguishing between tenure types (ownership or rental), thereby considering housing prices in aggregate terms. The third component explores emerging patterns of housing demand, emphasizing recent dynamics within the housing market that may signal shifts in demographic, economic, or spatial preferences.

To support the analytical framework, synthetic indicators (SIs) were developed by applying PCFA, a multivariate statistical technique designed to reduce dimensionality in complex datasets. The resulting indicators are statistically robust, providing a simplified yet comprehensive overview of complex housing dynamics without compromising the depth and relevance of the original information.

To perform this analysis, after value standardization (using the z-score method) for each one of the parameters, a correlation matrix was constructed for each of the cases to extract the eigenvalues, thus making it possible to develop the principal component score expression. This process is better detailed in the Appendix.

Finally, the fourth component of the analysis involves aggregating the three previously constructed synthetic indicators through a clustering procedure using the k-means algorithm. This step aims to generate a comprehensive typology that synthesizes the housing situation across Portugal, highlighting territorial patterns and spatial disparities. In addition, regression analyses were conducted to investigate the relationships and explanatory power of the synthetic indicators further.

The following table (Table 2) presents the attributes and variables selected for constructing each synthetic indicator.

**Table 2.** Selected variables for synthetic indicators on housing supply, affordability, and market dynamics.

| Indicators | Variables/Attributes |
|---|---|
| 3.1 Housing Supply vs. Demand | Average building age |
| | Percentage of Vacant Dwellings |
| | Household Variation (2011 – 2021) |
| | Variation in Classic Family Dwellings (2011 – 2021) |
| 3.2 Affordability | Income |
| | Housing buying price |
| | Housing rental price |
| | Consumer Price Index (CPI) |
| 3.3 New Demand Patterns | Percentage of Primary Residences |
| | Percentage of Rental Contracts |
| | Percentage of Completed Transactions |

While the results derived from the synthetic indicators are both interpretable and informative, additional analyses were conducted to deepen the understanding of the categories associated with each indicator. Specifically, relationships between selected critical variables—identified as essential to characterizing each dimension—were further explored. It was established by the authors that, taking into account the min and max value for each SI and to better compare them, the number of five intervals was chosen.

K-means clustering was applied to group territorial units based on similarity, with the optimal number of clusters for each case determined through an elbow method

analysis (see Appendix) [18–20]. Subsequently, additional linear regression models were employed within each cluster to examine the internal dynamics and strengthen the interpretative framework of the findings.

### 3.1 Housing Supply vs. Demand

This indicator enables a simultaneous analysis of the evolution in the number of dwellings and households alongside the average age of the building stock, thereby highlighting contrasts between more and less dynamic territories. The lowest and negative values (e.g., ranging from –2.42 to –0.45 standard deviations below the mean) are associated with municipalities characterized by an older housing stock and a higher proportion of vacant dwellings, a significant share of which are likely uninhabitable. In contrast, higher and positive values correspond to areas that experienced above-average growth in the number of dwellings and households between 2011 and 2021. These areas also align with the pattern identified in Indicator 3.3, which reflects the predominance of primary residences relative to other forms of occupancy, such as secondary residences and vacant units. The results are illustrated in Fig. 1.

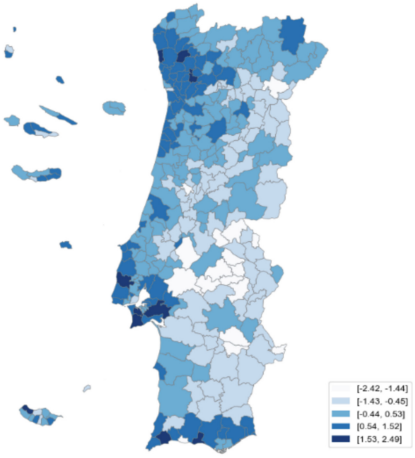



**Fig. 1.** Spatial dynamics of housing stock renewal and demographic growth (2011–2021).

### 3.2 Affordability

The affordability indicator enables the comparative analysis of housing market prices, household income, and purchasing power across municipalities. Higher indicator values correspond to territories where all variables exceed the national average. However, it is essential to note that elevated values do not inherently signify a balanced relationship between housing costs and income levels. A more detailed examination of this dimension is provided in Sect. 3.4, which identifies key scenarios, including (i) municipalities where housing prices exceed what would be expected based on income levels and (ii)

municipalities where prices are relatively low in comparison to household incomes. These patterns are reflected in the present analysis, particularly in values ranging from 0.19 to 1.66 standard deviations above the mean.

It is not possible to directly infer economic accessibility levels or to unequivocally identify municipalities under the greatest housing pressure solely from this indicator. Nonetheless, intermediate and lower values are indicative of a greater misalignment between the analyzed variables. This may occur in contexts where both prices and incomes fall below the median or where prices are below the median while incomes remain comparatively higher (e.g., values between −1.28 and 0.19 standard deviations). These spatial dynamics are illustrated in Fig. 2.

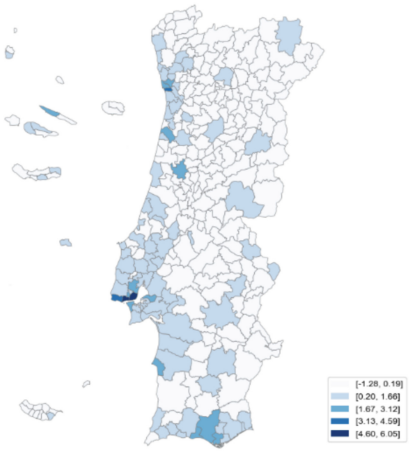



**Fig. 2.** Spatial distribution of housing affordability: the relationship between prices, income, and purchasing power.

### 3.3 New Demand Patterns

The housing market dynamics indicator, which integrates variables such as the number of rental contracts, the volume of residential property transactions (purchases/sales), and the proportion of owner-occupied primary residences, distinguishes municipalities exhibiting higher market activity and turnover levels. These spatial patterns of market dynamism are illustrated in Fig. 3.

### 3.4 Final Territorial Patterns

An integrated analysis of the three previously constructed composite indicators was conducted to identify and interpret distinct territorial patterns. Based on the results of the elbow method (see Annex I), the selection of three clusters was deemed methodologically appropriate, offering a meaningful balance between explanatory power and model parsimony.

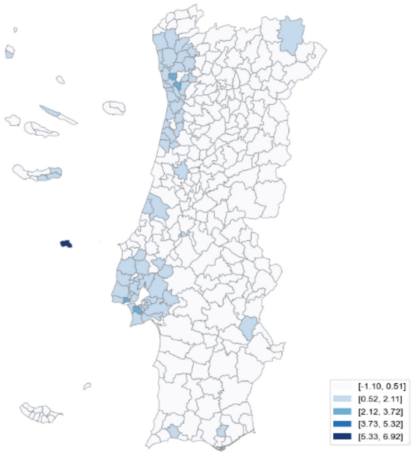
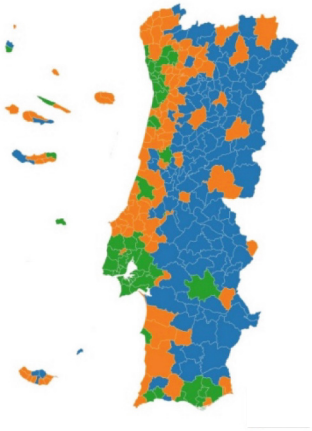



**Fig. 3.** Spatial patterns of housing market dynamism: transactions, rental activity, and owner-occupancy.

The resulting clusters allow for the differentiation of territorial profiles, as illustrated in Fig. 4.



| | Affordability | Housing Supply vs. Demand | New Demand Patterns |
|---|---|---|---|
| Cluster 1 | -- | --- | -- |
| Cluster 2 | ++ | + | ++ |
| Cluster 3 | +++ | ++ | +++ |

**Fig. 4.** Spatial Clustering of municipal housing profiles according to composite housing indicators. (Color figure online)

Cluster 1 (blue): Mainly composed of municipalities commonly associated with the country's interior regions, with a few exceptions. This cluster is where all three composite indicators show the least significant values: the housing stock has evolved modestly, the housing market is less dynamic, and both prices and/or incomes are relatively low compared to the average.

Cluster 2 (orange): Associated with coastal municipalities (excluding the metropolitan areas) but also includes some inland municipalities such as district capitals (Viseu, Bragança, Guarda, Castelo Branco). In these municipalities, prices and incomes are particularly high, which is reflected in the intensity of the economic accessibility indicator. At the same time, the number of transactions and new rental contracts points to a more dynamic housing market. These municipalities also recorded positive changes in the number of dwellings and households between 2011 and 2021.

Cluster 3 (green): Associated with metropolitan areas and their surrounding municipalities, including some municipalities in the Algarve region and other district capitals such as Aveiro, Coimbra, and Évora. These municipalities stand out for having the highest values across all indicators, showing a significant disparity compared to other territories.

### 3.5 Complementary Cluster and Regression Analysis

A two-stage methodological approach and its resulting territorial typology, combining affordability analysis and housing supply-demand dynamics to produce a final clustering of Portuguese municipalities.

To assess housing affordability across municipalities, a bivariate typology was constructed using two key variables: total housing price (2021) (x-axis) and average household income (2021) (y-axis). Municipalities were classified into six distinct categories based on their relative position to the national medians (red and blue dashed lines) and the least squares regression line (green). This approach allows for a nuanced interpretation of affordability dynamics grounded in observable deviations from national averages and expected trends. This analysis is seen in Fig. 5.

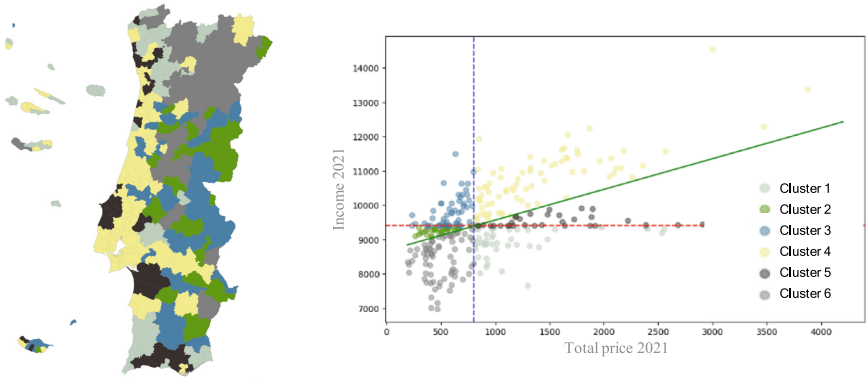



**Fig. 5.** Spatial clustering of municipal housing profiles according to total housing price (2021) and average household income (2021) (Color figure online)

The classification is as follows:

- Cluster 1 (light green): Territories positioned below the income median and above the price median, indicating critical affordability pressure.

- Cluster 2 (light blue): Cases above the regression line represent municipalities with income levels higher than expected given local housing prices, suggesting relatively favourable affordability ratios.
- Cluster 3 (blue): Municipalities above the income median and below the housing price median suggest areas with more favourable affordability conditions.
- Cluster 4 (yellow): Municipalities above both medians, corresponding to high-cost and higher-income environments, where market dynamics may remain relatively balanced.
- Cluster 5 (dark grey): Areas below both medians, typically associated with lower-cost but also lower-income contexts, where affordability issues may persist despite low prices.
- Cluster 6 (light grey): Municipalities below the regression line, where income is disproportionately low relative to housing prices, indicating worsened affordability conditions.

Following the previous analysis, the next Fig. 6 applies a similar methodological approach, using the same segmentation logic—based on medians and the regression line—to examine the relationship between the number of classic family dwellings and the number of private households. This allows for the identification of distinct territorial typologies regarding the balance (or imbalance) between housing supply and local household structure.

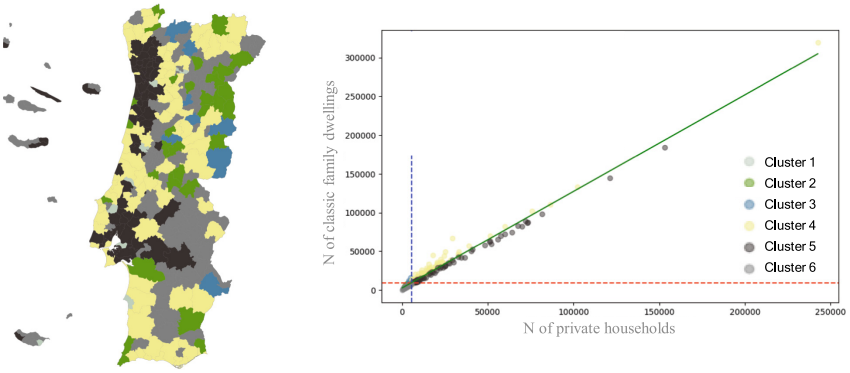



**Fig. 6.** Spatial clustering of municipal housing profiles according to the number of classic family dwellings (2021) and the number of private households (2021) (Color figure online)

The combination of the two previous analyses—focusing respectively on affordability dynamics and the balance between housing supply and household structure—resulted in the integrated analysis presented below. This synthesis enables a broader territorial classification, capturing areas with overlapping or divergent housing pressures and providing a more comprehensive view of the structural dynamics shaping housing accessibility in Portugal (Fig. 7).

The integrated analysis reveals four distinct territorial patterns across Portugal:

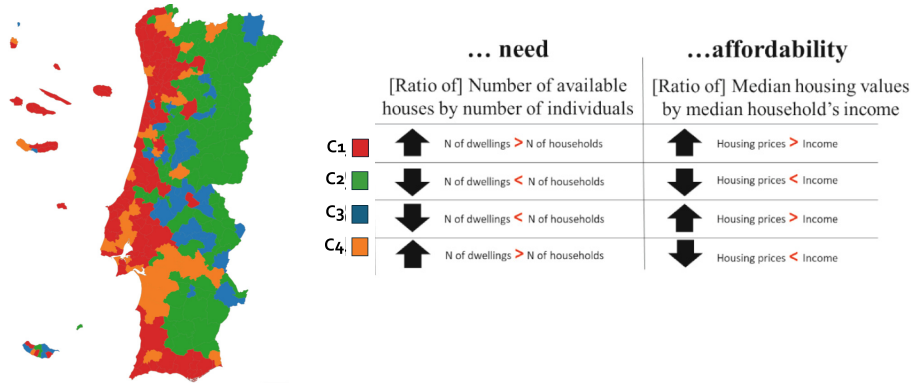



**Fig. 7.** Spatial clustering of municipal housing profiles according to the needs and affordability. (Color figure online)

- Cluster 1 (red) highlights municipalities under compounded housing pressure, with high affordability constraints and limited alignment between housing supply and demand. These are mainly concentrated along the southern coast and some inland southern regions.
- Cluster 2 (green) represents areas with more balanced conditions, where income and housing costs are relatively aligned, and the housing supply meets household needs. These are typically found in central and northern interior municipalities.
- Cluster 3 (blue) identifies territories where affordability appears favourable but may conceal mismatches in supply dynamics—suggesting potentially underutilized housing stock or stagnant markets.
- Cluster 4 (orange) includes municipalities where affordability issues are less pronounced but where housing stock evolution may not have kept pace with demographic shifts. These are often transitional or peri-urban areas.

This analysis gives a slightly different view from the one that uses the SI. With this, we tried to illustrate that some municipalities that, by comparison, don't seem too critical regarding affordability using the SI appear as critical in this last analysis.

## 4 Discussion

The analysis confirms the existence of significant spatial disparities in housing dynamics across Portugal, underscoring the complex interplay between structural housing characteristics, affordability, and emergent demand patterns. Despite a nominal surplus in housing stock, effective accessibility remains uneven, particularly for low-income and vulnerable groups, revealing a critical mismatch between housing availability and adequacy.

The findings reinforce that metropolitan and coastal municipalities—especially Lisbon, Porto, and the Algarve—continue to experience intense affordability pressures driven by tourism, short-term rentals, and foreign investment. These areas are characterized by high prices, increased market turnover, and demographic dynamism but also

reveal growing exclusionary housing access trends. In contrast, interior and low-density municipalities face stagnation, high vacancy rates, and aging housing stock, further deepening socio-territorial inequalities.

A relevant insight emerges from the comparison between the synthetic indicator-based clustering and the bivariate typology combining affordability and supply-demand dynamics. While both approaches capture similar territorial divides, the latter proves more sensitive in highlighting affordability tensions in inland municipalities often overlooked in national-scale metrics.

This study emphasizes that a one-size-fits-all housing policy is inadequate for responding to Portugal's territorial contexts' diversity. Instead, tailored strategies that account for both market dynamics and socio-demographic realities are necessary. Addressing spatial inequalities in housing will require targeted investment and rehabilitation, particularly in underperforming regions, and stronger coordination across national and municipal scales, along with clear mechanisms to monitor, evaluate, and adjust policy implementation.

## 5 Conclusion

This study conducted a spatially disaggregated assessment of housing dynamics in Portugal, using multivariate and geospatial methodologies to uncover structural imbalances and territorial disparities. Through the integration of census data, market indicators, and socioeconomic variables, it was possible to construct synthetic indicators that revealed not only well-known affordability tensions in metropolitan and coastal areas, but also emerging pressures in inland and peri-urban municipalities.

The analysis demonstrated that nominal housing availability often fails to translate into real accessibility, especially where market prices exceed local purchasing power or housing supply lags behind demographic shifts. The complementary typology further revealed municipalities whose affordability challenges may be obscured by aggregated indicators, reinforcing the need for granular and multidimensional assessments.

Portugal's housing challenges are shaped by more than just supply —they reflect deep-rooted issues of affordability, inequality, and spatial mismatch [21]. Addressing these requires territorially differentiated policies that align with local needs, greater coordination between national and municipal interventions, and robust monitoring systems. As new market forces—such as tourism and foreign investment—continue to reshape demand, future housing strategies must emphasize rehabilitation, rental regulation, and the integration of housing into broader territorial cohesion frameworks, ensuring that the constitutional right to housing is realized across all regions.

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## Appendix

1. PCFA results

The standardization method used was the z-score method. After this, the methodological approach is similar to the one used by Wiersma et. al [15]. The principal components (PC) extracted summarize the underlying structure of the dataset, which is then divided for each corresponding SI. The factor loading indicates the strength and direction of each attribute's contribution to the first component and so on. In the other hand, the communalities tell the proportion of each variable's variance that is explained by the respective component. Only the first factor appears because the Kaiser Criterion was used, and for all of the SIs, the first components turned out to be the most significant (eigenvalue > 1), which means that the first factor can explain most of the variance. The results are in Table 3.

**Table 3.** PCFA results

| SI | Attribute | Loading | Communalities |
|---|---|---|---|
| Housing Supply vs. Demand | Average building age | –0.691292 | 0.477885 |
| | Percentage of Vacant Dwellings | –0.552037 | 0.304744 |
| | Household Variation (2011 – 2021) | 0.803568 | 0.645722 |
| | Classic Family Dwellings (2011– 2021) | 0.595093 | 0.354136 |
| Affordability | Income | 0.720293 | 0.518822 |
| | Housing buying price | 0.823472 | 0.678107 |
| | Housing rental price | 0.728841 | 0.531209 |
| | CPI | 0.911034 | 0.829983 |
| New Demand Patterns | Percentage of Primary Residences | 0.688881 | 0.474557 |
| | Percentage of Rental Contracts | 0.658927 | 0.434185 |
| | Percentage of Completed Transactions | 0.876827 | 0.768825 |

2. The elbow method for K-Means Clustering

The elbow method is used to determine the ideal number of clusters in K-Means, since it helps to balance the trade-off between the variance within clusters and the number of clusters. It is often complemented with a visual support that consists of plotting a chosen range of cluster counts against the within-cluster sum of squares. The graphical result

of this is a curve. At the point where the curve starts to "stabilize" is the ideal number of clusters to choose.

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