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Urban Transformation: A Comparative Analysis of Building and Population Densities in Urban Housing Settlements with Diverse Textures in Terms of Sustainability—The Case of Bursa Osmangazi

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Abstract: The aim of this study is to evaluate the urban transformation processes in the context of urban sustainability by analyzing the population and building density trends of four different housing settlement textures that have developed in Bursa Osmangazi since the 1960s, when the industrialization process began in Turkey. The methods include a detailed analysis of population changes and building and population densities. The results show that, in the areas developed between 1960 and 2004, population growth has either stopped or declined, and there are irregularities in building and population densities. This situation indicates the problems arising from planning and infrastructure deficiencies in urbanization processes. The earthquake risk in housing areas from this period especially increases the urgency of renewal and transformation processes. This study emphasizes the necessity of urban-scale solutions to manage the urgency of renewal in earthquake-prone regions. It highlights the need to handle pre-2004 areas together in the urban transformation process to balance densities. In this context, the importance of density transfer, the protection of property rights, and the effective management of transformation processes are underlined for urban sustainability.

Keywords: urban transformation; building density; population density; urban sustainability; urban housing

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1. Introduction

In the early 18th century, the distribution and appearance of cities, which were no different from the Middle Ages, underwent unprecedented and irreversible changes and transformations starting from the early 19th century due to the industrialization process in Northwestern European countries and the USA. Cities, which were at the center of this transformation, grew and densified as a result of profound changes in the social structure during the production process. The concentration, diversification, and mechanization of production led to the formation of production centers and the rapid migration of the rural population to these centers. As a result, the industrialization process has shaped the urbanization of Turkey over the last 60 years [1]. The demographic transformation resulting from intensive industrialization caused the formation of different social, socio-economic, sociological, physical, and spatial structures in cities, creating multi-layered, multicultural urban fabrics. While development in these cities manifested itself in trade

and production areas and their organization, social segregation processes became most evident in settlement areas.

Urban renewal emerged in Europe after World War II with the aim of rebuilding cities that were destroyed. In Turkey, however, from the 1960s onwards, migration towards city centers where industry was concentrated led to uncontrolled and unregulated urbanization. In subsequent years, factors such as economic developments, housing problems, and natural disasters brought the reconstruction of urban areas and especially settlement areas, which had become dysfunctional in economic, physical, and environmental contexts, making them resistant to natural disasters, to the agenda.

In urban transformation processes managed by central and local governments in Turkey, new settlement areas, which are usually planned to be high-density and multi-story with rapid production and low cost, bring a new image to the city's identity. However, the initially targeted social, economic, environmental, and other goals are often not achieved; elements such as quality, aesthetics, livability, and socio-physical infrastructure can be neglected (e.g., Osmangazi Toki Doğanbey Settlement) [2]. Such settlement areas create an atmosphere of unrest and dissatisfaction among people. These problems emphasize the necessity of considering a broader perspective in terms of quantity and quality. Quantitative changes also bring qualitative effects [3].

At the 2015 United Nations Sustainable Development Summit held in New York, the 2030 Sustainable Development Goals (SDGs), comprising 17 main themes, were adopted and signed by 193 countries. Within the scope of these goals, under the heading "Sustainable Cities and Communities", the aim of "Safe and Accessible Housing" was expressed: by 2030, ensuring access for all to adequate, safe, and affordable housing and basic services and upgrading slums. Furthermore, the agreement highlighted the target set out in the Sendai Framework for Disaster Risk Reduction 2015–2030, which includes enhancing disaster preparedness for effective response and rebuilding better during recovery, rehabilitation, and reconstruction, as well as significantly reducing economic, physical, social, cultural, and environmental losses caused by disasters [2].

In recent years, urban transformation projects carried out in Turkey generally aim to increase the structural and population density of existing areas to finance demolition and reconstruction. However, the increase in density without adhering to any specific purpose or program in these areas results in significant issues such as the displacement of the resident population, the influx of a new population, the neglect of social and technical infrastructure, and the destruction of the city's silhouette and historical fabric. Additionally, the relationship between population and building stock in urban settlement areas cannot be established, leading to inefficiencies in usage.

Instead, more comprehensive and sustainable solutions should be adopted by conducting necessary density analyses of the areas. The proposed solutions should include the assessment of existing building stock, the consideration of socio-economic and environmental factors, infrastructure development, and social participation. Improving the urban fabric, enhancing quality of life, and increasing resilience to natural disasters should be prioritized in the transformation processes.

Urban transformation that encompasses not only physical changes but also social and economic improvements will contribute to the development of more sustainable and livable settlement areas for communities. In urban transformation projects that will take place in settlement areas with different textures, the main purpose of this study is to determine strategies related to transformation in line with sustainability principles by considering the structure and population densities of the area holistically on an urban and regional scale, and restructuring cities in terms of their physical, social, economic, and environmental aspects. Osmangazi is located in the first-degree earthquake zone on the North Anatolian

Fault. Furthermore, a large part of the urban settlement areas that developed after 1963 were built on alluvial soil with poor-quality materials and methods, while some were built according to the standards of the day. However, due to the inadequacies and lack of control in the construction sector in Turkey at the time, these areas have become highly susceptible to today's earthquake impacts.

Looking at previous urban transformation projects in Turkey, it has been observed that on-site transformations could not integrate with their surroundings and were insufficient in solving neighborhood problems. Urban transformation projects carried out at the scale of building islands have failed to provide the necessary social facilities for the neighborhood. In urban transformation projects at the neighborhood scale, it has been seen that property rights were not adequately protected. Unlike previous practices, this article defines parameters that highlight efficiency in terms of population and structure by maintaining the social fabric and keeping the population in place during the transformation of risky settlement areas within the context of physical sustainability. The primary aim of this study is to determine urban renewal processes and strategies that, in line with sustainability principles, address structure and population densities and the use of urban areas, improve area settlement and usage, make existing urban settlement areas resistant to natural disasters, and simultaneously achieve the goal of safe and accessible housing for urban transformation projects to be implemented for settlements with different textures.

2. Materials

2.1. Urbanization in Low-Income Countries During the Industrialization Process

In low-income countries, cities experiencing rapid industrial growth have witnessed a rapid population increase in a short time, leading to numerous issues such as unhealthy infrastructure and building masses, air pollution, transportation problems, inefficiencies in local government infrastructure investments, and spatial segregation based on socio-economic or ethnic lines. The urban fabric in these countries exhibits different characteristics in terms of demographics, economics, and social aspects. Urbanization in these countries progresses faster than industrialization. In this context, globally, middle-income countries have evolved from industrial societies to knowledge societies, and industrial production areas have shifted to low-income or developing regions [4].

Additionally, the economic structure of these countries relies more on the service sector rather than industrial production [5]. Furthermore, social stratifications and spatial segregations arise due to the differences in socio-economic income levels caused by the emergence of various job sectors in the city. This differentiation, along with individual ownership, leads to the development of various urban housing fabrics based on legal, administrative, physical, cultural, and typological factors. These differences result in noticeable texture variations in settlement areas, influenced by factors such as physical boundaries, building densities, population densities, and the qualities of urban open spaces within the same city centers.

One of the differences that should be taken into account between middle-income and low-income countries is population densities. The densities in the cities of low-income countries are much higher than in middle-income countries [6]. Therefore, density is one of the main criteria used to measure the congestion or spread of an urban settlement [7]; thus, questioning high-density development becomes crucial in testing the model's suitability for a specific country [8]. The accumulation of urban population, which exceeds the rate of rapid industrialization along with population growth, also leads to income distribution inequality.

According to Çamurcu, while the population growth rate in middle-income countries varies between 0.5 and 1% on average, this rate is around 2% in lower-income countries and

approximately 2.5–3% in the lowest income countries. This situation presents the world with more complex and difficult-to-solve problems. In Figure 1, the GINI Coefficient is compared with urban population densities and urban population rates. According to this figure, it can be said that urban population and population density are parallel to income distribution inequality. Additionally, Figure 2 shows that the population growth rate in lower-income countries will continue at the same level until 2060 and then exhibit a certain downward trend until 2100.

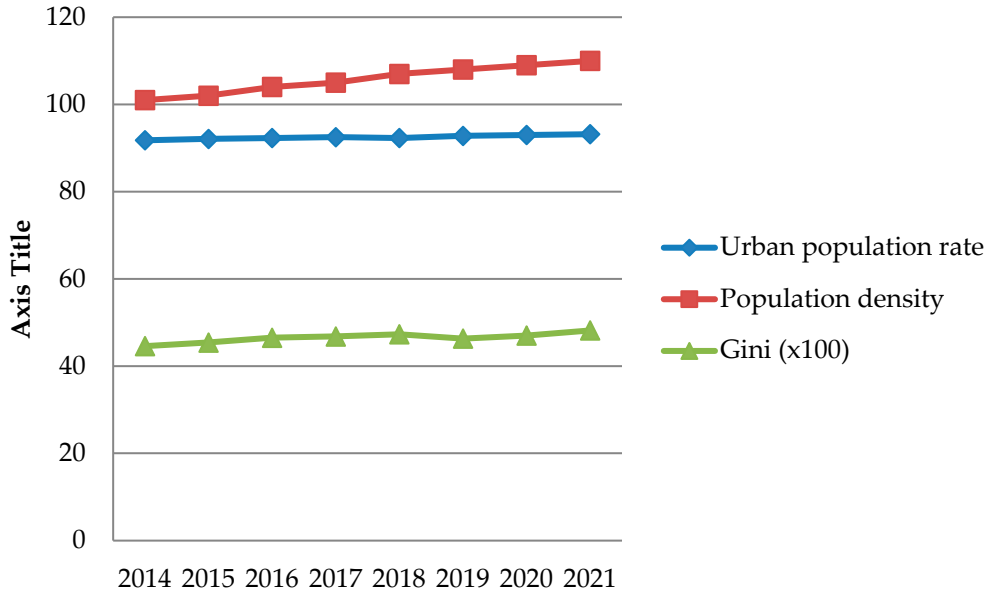


Figure 1. Income distribution imbalance, population density, and urban population ratio in Turkey after 2011 (population density is taken as persons/km^2 as urban densities are considered).

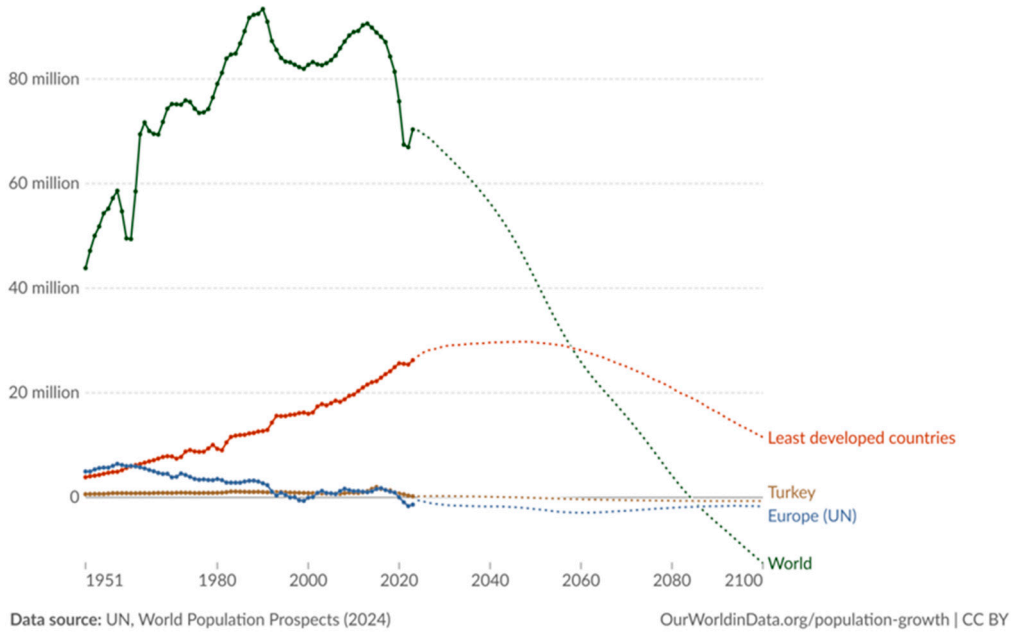


Figure 2. Population projection of Turkey and the world between 1951 and 2100. Annual population growth. Available online: https://ourworldindata.org/grapher/annual-population-growth?time=earliest..2100&country=OWID_WRL~TUR~Least+developed+countries~Europe+(UN) (accessed on 19 November 2024).

In general, urban structure and population density can bring about both advantages and disadvantages. According to Jacobs [9], the advantages of density include increased

walkability, the formation of tightly knit communities, and the concentration of resources. Many studies emphasize the importance of high population density in supporting public transportation and achieving sustainable development. However, there is very little information on how to design settlement areas in a way that discourages people from using cars [10].

In addition to high density, there are other criteria that should be used to measure urban congestion. According to Burton [11], in addition to population density, building density and sub-center density are also among the criteria for congestion; moreover, mixed-use and density should also be measured. Min et al. [12] list these criteria as population density, land use, road network characteristics, accessibility, and settlement density. According to Galster et al., these criteria include density, continuity, concentration, clustering, centrality, core formation, mixed-use, and proximity.

Based on all these approaches, the population, structure, and function of the urban area, and its density and spread become important areas of discussion to form future perspectives. Currently, there are two different methods being followed in urban transformation projects. Firstly, by increasing the building densities in existing urban settlements, the financing of urban transformation is provided. The second way is to produce and sell new houses in reserve areas designated by law, which are temporarily allocated for the accommodation of the existing population in urban transformation areas. In this case, since the reserve areas deviate from their purpose, the temporary housing problem of the population cannot be solved, which leads to hesitancy among the public in participating in urban transformation projects. From this perspective, current and proposed densities gain importance. Therefore, the main issue here is to reach the optimum values of the limits related to density or sprawl.

2.2. Post-1960 Industrialization Period Urbanization in Turkey and Osmangazi

With the shift in industrialization to the private sector after the 1960s, industrialization and urbanization in Turkey showed significant rapid development. The industrialization process that took place in European cities in the 19th century emerged in Turkey in the mid-20th century. This period also coincides with the years when the global population growth rate began to rise.

The industrialization process in Turkey, unlike industrialization in Europe, coincided with the rapid global population increase. The Development Plans prepared and implemented by the State Planning Organization (DPT), established under the 1961 Constitution to ensure Turkey's development, guided Turkey's economic growth and led to significant migrations to the cities where industries were established by the private sector [13].

The rapid population growth in these cities, inequality in income distribution, poverty among migrant masses, inadequate urban infrastructure, and the lack of necessary legal, technical, physical, or financial structures to meet the housing needs led to the provision of shelter needs in the cities largely through illegal means. In the early 1960s, the quickest solution provided by economically weak groups was the construction of slums (gecekondu). Initially, people trying to settle in the cities started to build temporary slum structures in areas close to industrial zones, often on state lands, extending to regions with poor topographic conditions. These structures could be easily rebuilt repeatedly when demolished [14].

Over the years, these structures continued to grow with additions and were transformed into property through zoning amnesty laws. In the continuation of this period, especially from the 1970s onwards, similar illegal settlement areas emerged on agricultural lands at the peripheries of city centers. In these areas, which are described as unregulated settlement areas, although the lands were illegally opened to settlement, they became properties unlike slum settlements. Additionally, these areas were illegally transformed into

small building parcels, leaving only minimal space for roads. The socio-economic status of the population settling in these areas is relatively higher compared to the population that initially migrated, but, due to the lack of necessary legal regulations, these areas were also constructed without meeting the required technical conditions and geomorphological suitability. According to Atkinson, illegal slums and irregular settlement areas, which can be defined as informal, emerged as a result of housing shortages and migrations caused by inadequate government planning and speculative housing markets [15]. Additionally, during this period, detached houses from the pre-industrialization era were demolished, and, legally, higher-density apartments with multiple independent housing units, as well as cooperative and partially public housing, were constructed.

After the 1960s, four different urban housing settlements developed in Osmangazi: illegal (slums and unregulated settlements) and legal (apartments and mass housing) (Figure 3).

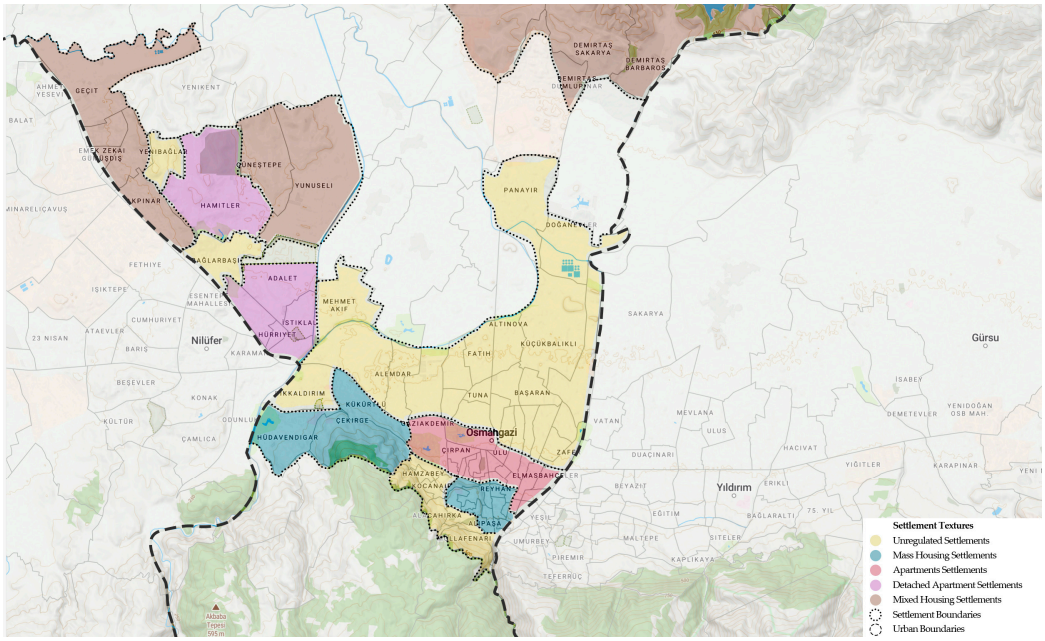


Figure 3. Urban settlements developed after the 1960s.

Slum and unregulated settlements differ in terms of property characteristics and location choice. Slum settlements generally developed in the foothills of Uludağ in Osmangazi and in areas unsuitable for settlement. Because slum areas cover a very small area compared to the general settlement in the entire urban settlement area of Osmangazi, they were excluded from the scope of this study. In contrast, unregulated settlement areas generally developed in the city center and its surroundings, especially on the agriculturally significant Bursa Plain. These areas also have a geomorphological structure that poses a significant risk in terms of earthquake effects. Apartments and mass housing areas have also differentiated in terms of settlement and construction texture. Apartment settlements were built in the city center in an adjacent order, while mass housing areas developed with multiple building blocks located on a single building parcel at the city's peripheries. Additionally, the settlement areas considered in this study were shaped not only by legal regulations but also by socio-economic income levels, ethnic structure/kinship relations, and production/financing relationships. Finally, detached apartments began to develop within the zoning plans prepared after 2004. However, detached housing (villa) areas that developed after 2004 have not been evaluated because they do not require a transformation process today, unlike those that developed between 1960 and 2004.

2.3. Development of Urban Fabric and Urban Transformation Process

These housing areas, which have developed based on different dynamics, have different physical textures and densities depending on land ownership structures, kinship and neighborhood relations, housing production processes, and the income level of the population.

Apartment settlements include multi-family settlement buildings that are common in urban areas. These buildings are designed to accommodate residents at higher densities and are often part of planned urban development projects. They are generally legal settlement areas that have developed in the areas surrounding the city's commercial center and were built in place of old detached houses after the 1960s. An apartment and a detached house from the pre-1963 period can be seen in Figure 4. A map that shows the physical structure of apartment settlement areas is given in Figure 5.



Figure 4. An apartment and a detached house from the pre-1963 period.

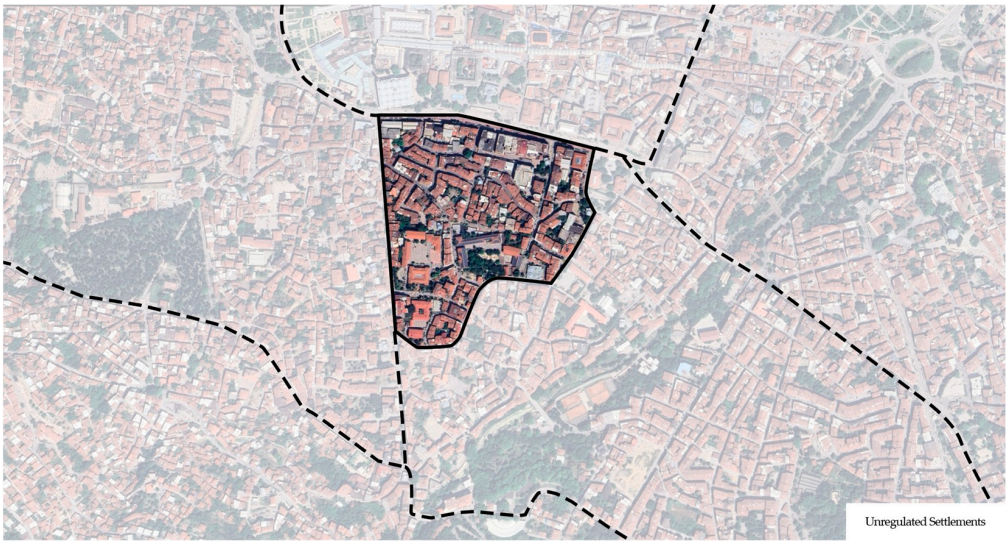


Figure 5. A satellite image of the apartment settlement.

These areas were made possible by the 1963 Condominium Law, which allowed the construction of multiple settlement units within a single building. These settlement areas, which were built with the necessary projects prepared by real estate developer companies and legal permits, have today become the city's affordable housing areas, inhabited by developing countries communities (Figure 6). These settlement areas were chosen according to socio-economic income levels, and, thus, they are areas without kinship relations. According to TUIK data, approximately 10% of the population of Osmangazi resides in apartment settlements.

Construction Characteristics Apartment Settlements	There is a legal and planned settlement.
	Generally, buildings have no front gardens and unusable back gardens.
	There is adjacent construction.
	There is no floor regime. It developed after 1960.
	The usage density of the base area is very high.
Issues in the Area	There is insufficient public space for social and technical areas.
	The population density is very high.
	Gardens left on parcels are unusable.
	The population is decreasing.
	Settlements are located in central areas and have no room for expansion.
Opportunities	Settlement areas are located in central regions.
	The night population density is decreasing.
	The construction in the area has been carried out legally.
	The buildings have been constructed according to plans.

Figure 6. Construction characteristics of apartment settlements, problems and opportunities in the settlement area.

Unregulated settlements developed after the 1960s on the agricultural lands of villages located at the borders of the historical center of the city and the Bursa Plain (Figure 7). These areas were divided into small building parcels without leaving any space for social and technical areas other than roads, and they provided illegal solutions for the shelter problems of new migrants to the city (Figures 7–10).



Figure 7. A satellite image of the unregulated settlement.



Figure 8. A street in an unregulated settlement area.



Figure 9. An informal building in unregulated settlement.

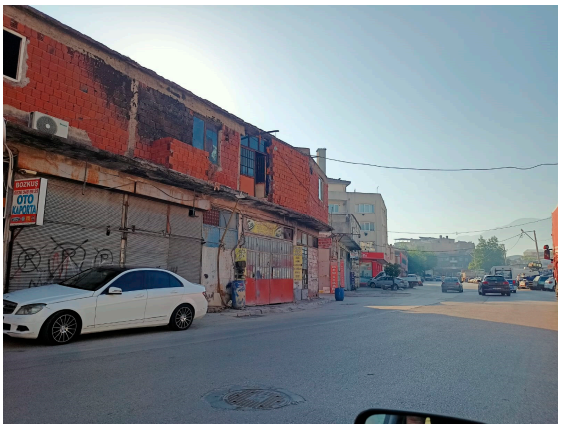


Figure 10. A derelict warehouse building in an unregulated settlement area.

In these settlement areas, the person who purchases a building parcel generally creates multiple settlement units gradually for the shelter of themselves and their family. Additionally, during the process of migration to the city, it is observed that relatives and fellow townspeople prefer the same settlement area. Therefore, kinship and neighborhood relations are strong in unregulated settlement areas. The population residing in these areas constitutes approximately 48% of the population of Osmangazi. Construction characteristics, issues and opportunities are explained in Figure 11.

Construction Characteristics of Unregulated Settlements	The settlement has been formed illegally and without adhering to regulations.
	Generally, buildings have no front gardens and unusable back gardens.
	There is adjacent construction.
	There is no floor regime.
	It developed after 1960
	The usage density of the base area is very high.
	There is insufficient public space for social and technical areas.
	Buildings were not constructed based on any project.
Issues in the Area	The population density is very high.
	Gardens left on parcels are unusable.
	The population is decreasing.
	Settlements are located in central areas and have no room for expansion.
Opportunities	Settlement areas are located in central regions.
	The night population density is decreasing.

Figure 11. Construction characteristics of unregulated settlements, problems and opportunities in the settlement area.

Mass housing settlements are types of housing constructed especially as housing cooperatives and public lodgings in the post-1960 period. These settlement areas have continued to develop in new urban areas after 2004, with the production process transitioning from cooperatives to real estate developers. These areas are legally constructed housing areas (Figure 12).

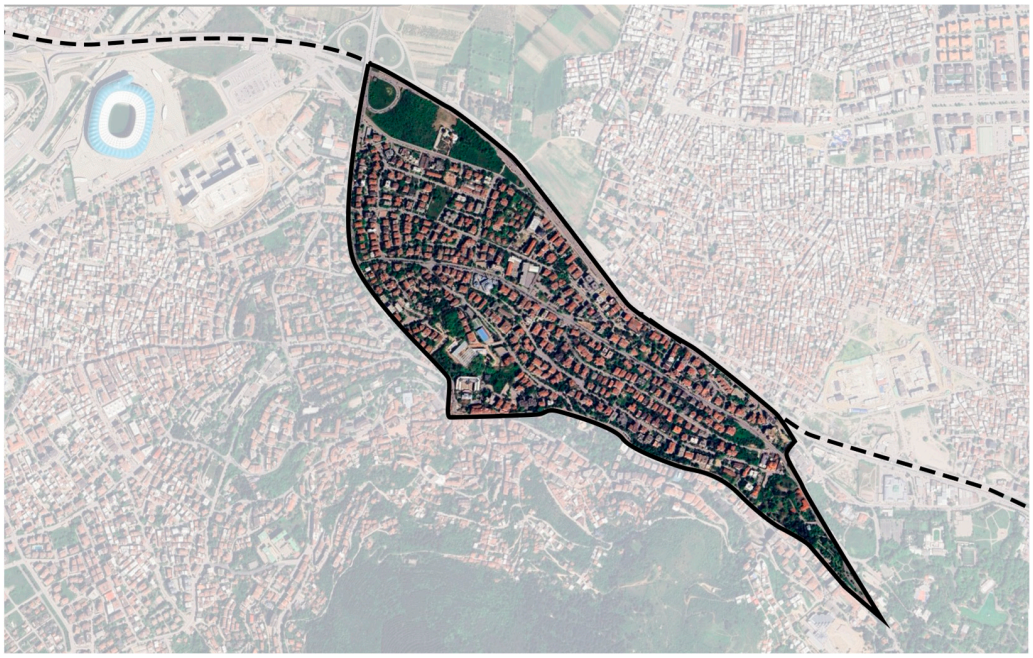


Figure 12. A satellite image of the mass housing settlement.

Mass housing areas that continue to develop today are expanding in different urban areas for people of various socio-economic levels. The person who buys a building parcel intends to sell the produced housing units to users, and each independent housing unit is delivered to the buyer under market conditions. Therefore, kinship relations are not present in these settlement areas (Figures 13 and 14). Approximately 8.75% of the population of Osmangazi resides in mass housing areas. Construction characteristics, issues and opportunities are explained in Figure 15.



Figure 13. A photo of a mass housing area.



Figure 14. A different photo of a mass housing area (Kükürtlü settlement).

Construction Characteristics of Mass Housing Settlements	There is a legal and planned settlement.
	There are settlement areas developed both after 1960 and after 2004.
	The buildings in the area are constructed as detached and with gardens.
	A floor regime has been implemented in the area.
	There are not many illegal additions or alterations.
	The population density is much lower than that of urban settlement areas (107 people/ha).
	In the settlement area after 1960 (Kükürtlü), the population remained unchanged between 2007 and 2023.
	Therefore, it has the potential to attract population.
	In the settlement area after 2004 (Yunuseli), however, the population has increased approximately 2.5 times.
Issues in the Area	Buildings pre-2004 completed their economic lifespan.
	The construction in the area has been carried out legally.
	There are no illegal additions.
Opportunities	Technical and social infrastructure is present.
	It continues to attract population.
	The buildings have been constructed according to plans.

Figure 15. Construction characteristics of mass housing settlements, problems, and opportunities in the settlement area.

Detached apartment settlements are settlement areas that have developed after 2004. Detached apartment settlements are a hybrid between single-family houses and apartment buildings (Figure 16).



Figure 16. Physical structure of detached apartment settlement areas.

These structures offer some advantages of apartment living while also preserving the privacy and space advantages of detached houses. Although these settlement areas have been recently and legally constructed, there can be partially illegal additions (Figures 17 and 18). Construction characteristics, issues and opportunities are explained in Figure 19.



Figure 17. A photo of a detached apartment settlement.

A common feature of the unregulated housing settlements, apartment settlements, and mass housing settlements mentioned above is that they developed before the 17 August 1999 Marmara Earthquake, which was a significant turning point in Turkey's construction sector and urbanization in general. According to Taş and others, approximately 245,000 buildings, including 213,843 settlement structures, were damaged in the 17 August 1999 Marmara Earthquake, and approximately 1.5 million people were directly affected [16].

One of the main reasons that the concept of urban transformation is frequently used in Turkey is its location on significant earthquake belts. A large portion of the settlement areas in cities within earthquake zones was constructed rapidly, uncontrollably, and under primitive conditions between 1960 and 2004. These structures were built with poor materials and workmanship, without meeting technical requirements. Even if some of them met

the technical conditions of that period, they have either approached or reached the end of their economic life.



Figure 18. A different photo of a detached apartment settlement.

Construction Characteristics of Detached Apartment Settlements	There is a legal and planned settlement. There is public space available for social and technical areas. There is adjacent construction, and front and back gardens can be used in practice. There is a floor regime. There may be illegal additions. Development has occurred after 2004.
Issues in the Area	Illegal additions and extensions may arise in detached settlements
Opportunities	It is an area developed after 2004. It has a balanced density.

Figure 19. Construction characteristics of detached apartment settlements, problems, and opportunities in the area.

In recent years, the housing production process has continued with the claim of renewing urban areas against disaster risks, and legal regulations have been made in this direction [17]. However, the Law on the Transformation of Areas Under Disaster Risk cannot solve some issues regarding property rights, which are guaranteed by the constitution and international agreements. It determines general methods for different functions and densities of urban settlements. Additionally, in urban transformation practices carried out at the parcel or building island scale, construction densities are increased by going beyond the 1/100,000 scale master plans that determine the development policies of cities. Therefore, plans are halted through courts, leading to legal deadlocks that last for years. Due to these reasons, significant problems arise during the implementation of the Law on the Transformation of Areas Under Disaster Risk, and urban transformation projects can become unfeasible.

Urban transformation projects are generally carried out by private companies, and the financing of these projects is provided by increasing building density or building economic value. Therefore, in regions where urban rent is low or building and independent unit density is not increased, urban transformation projects cannot be implemented due to financing problems. The law does not approach urban transformation at the urban scale in

transformation processes that concern the entire city but rather targets transformation at the parcel and building block scale. This leads to new problems throughout the city.

For these reasons, although the said law encourages housing production, it has not achieved the desired success in renewing outdated urban textures. Today, the most important issue in discussions about urban transformation in settlement areas is how to relocate existing urban areas or how to carry out on-site transformations. In addition, since these applications are limited to a specific time frame, financing and property issues are also important. Furthermore, because these processes must be confined to a limited time period, how the process, financing, and property will be managed is the most critical concern.

3. Methodology

This study aims to analyze population, housing, and building densities in various housing settlements developed after the 1960s in the historical center of Bursa, particularly in the Osmangazi district. By examining these aspects, the goal is to eliminate existing land use errors, minimize urban sprawl as much as possible, and implement transformation applications in current areas during the revitalization process of existing and economically obsolete housing areas. The purpose is to highlight the density differences in urban settlement areas by comparing different textures and to develop a holistic approach to urban development. Additionally, this study aims to propose alternative methods for potential urban transformation projects based on the characteristics of the region and, while doing so, to develop an approach to urban housing textures specific to cities to solve existing problems based on the characteristics of the settlement unit.

Ersoy et al. state that, in the redevelopment process, a settlement unit should have qualities such as earthquake-resistant housing, adequate green spaces and social facilities, a calm, peaceful, and orderly living environment, contemporary condition-compliant housing, and strong social relationships. Moreover, the determination of the housing scale includes considering the compatibility of urban fabric and silhouette, the sufficiency of social facilities, urban location, the economic status of users and their participation in the process, the additional load on transportation, climate and other environmental data, qualified green areas, local housing identity, and expert opinions [18].

This study also aims to provide a foundation for efforts to Moreover, the determination of the housing scale includes considering the compatibility of urban fabric and silhouette, the sufficiency of social facilities, urban location, the economic status of users and their participation in the process, the additional load on transportation, climate and other environmental data, qualified green areas, local housing identity, and expert opinions eliminate the housing crisis and urban quality of life deficiencies in rapidly growing urban populations with significant socio-economic income inequalities and incomplete industrialization processes, which are prevalent in many cities worldwide. This article addresses land use, building, and population densities, and existing housing structures in the historical city center of Osmangazi, Bursa's most populous district, following the implementation of the First Development Plan (1963) prepared by the State Planning Organization (DPT). The selected settlements have different socio-economic, physical, and legal characteristics in their development processes while generally having a homogeneous texture within themselves. These settlements are detailed as follows: Apartment settlement areas, mass housing settlement areas, unregulated settlement areas, and detached settlement areas. Although slum areas differ from unregulated settlements in terms of ownership conditions, over the years, they have transformed into unregulated settlement areas as the lands settled by residents were sold to them by the state. Therefore, slum areas are considered within the scope of unregulated settlement areas. Neighborhoods are evaluated within administrative boundaries, and some non-residential areas in the selected neighborhoods (military areas,

agricultural areas, airports, etc.) are considered thresholds and are not included in the calculation of settlement areas.

Detached apartment structures, developed according to zoning plans and generally limited to two floors, known as family apartments, are not currently considered within the scope of urban transformation projects since they were built in the last 20 years. This study examines 9 settlement areas with 4 different housing textures. These neighborhoods are Zafer, Yeşilova, Soğanlı, Sakarya, İntizam, Maksem, Yunuseli, Kükürtlü, and Soğukkuyu. This study analyzes the population, the area of residential and non-residential (threshold) areas, population density in settlement areas, total population density (including thresholds), and housing and building density in the selected housing areas. Analyses were conducted in completed settlement areas ranging from 2 to 15 hectares. The analyses include the base area ratio of building blocks, total building density, the average area of existing housing units, the housing occupancy rate, the ratio of commercial function to total building density, the total number of housing units, and the number of floors of existing buildings. Population data for the year 2023 were analyzed and compared with the data for the year 2007. The year 2007 is notable due to the acceleration of the construction sector caused by the Mortgage Law, which enabled mortgage housing sales.

The analyses were conducted using the digital map and zoning application of the Osmangazi Municipality and the geographic information system, and the population data were obtained from the database of the Osmangazi Municipality Numbering Directorate. While organizing the data related to buildings, basement floors that are considered extensions and buried in the ground were not included in the evaluation. However, staircases and similar areas on building floors were included in the usable areas of the residential structures. In this study, population data were primarily used to determine urban population mobility after 2007. The population distribution of settlements between 2007 and 2023 is given in Table 1.

Table 1. Population distribution of settlements between 2007 and 2023.

	Unregulated Settlements			**Mass Housing Settlements**		**Apartment Settlements**		**Detached Apartment Settlements**	
	ZAFER	**YEŞİLOVA**	**SOĞANLI**	**KÜKÜRTLÜ**	**YUNUSELİ**	**MAKSEM**	**SAKARYA**	**İNTİZAM**	**SOĞUKKUYU**
2023	3961	12,350	25,932	11,333	40,845	4366	4243	3130	9705
2022	3976	12,487	26,111	1186	39,645	4444	4269	3201	9801
2021	4015	12,704	25,916	11,678	38,094	4426	4245	3338	9766
2020	4164	12,487	26,272	11,482	36,341	4532	4336	3522	9788
2019	4323	13,492	26,306	11,786	33,761	4740	4439	3739	9714
2018	4411	13,875	25,572	11,699	31,060	4852	4308	3860	9711
2017	4514	14,222	24,035	11,424	29,341	4921	4212	3964	9733
2016	4549	14,538	23,984	11,539	26,540	4960	4180	4101	9504
2015	4624	14,799	24,114	11,382	24,013	4927	4148	4178	9322
2014	4678	15,100	24,328	11,067	22,327	4904	4260	4304	9172
2013	4847	15,589	24,476	10,787	20,604	4985	4296	4376	8942
2012	5073	16,014	24,626	10,941	19,077	5107	4393	4520	8813
2011	5138	16,468	24,903	11,202	18,126	5172	8070	4584	8710
2010	5197	16,659	24,904	11,424	16,765	5235	7972	4609	8643
2009	5273	16,750	24,847	11,315	15,236	5335	7592	4650	8759
2008	5384	17,239	24,872	11,564	20,905	5394	4575	4799	8491
2007	5279	17,268	25,002	11,582	18,094	5367	4594	4805	8459

However, considering the population projection of the world and our country, it is predicted that the population of the city will grow based on the assumption that Bursa's annual population growth rate will be 0.92% between 2023 and 2030, according to the data from the Turkish Statistical Institute (TUIK-Turkey Statistic Agency).

4. Results

4.1. Density Analysis in Urban Settlements

The building and population densities in the selected settlement areas were compared based on cadastral maps, the Osmangazi Municipality database, and ADNKS (National Address-Based Population Registration System) data. The analysis results are presented in Table 2. The obtained data were evaluated in the Results section by taking the unit values of population and building density within the context of the urban planning principles of the Republic of Turkey Ministry of Environment and Urbanization. In this sense, the following limitations were used:

Building Density → 2.5 (Very High) → 1.25–2.0 (High) → 0.625–1.25 (Medium)
Population Density → 601 people/ha → 301–600 people/ha → 150–300 people/ha

Table 2. Density data of settlement areas.

	Population Density		**Building Density**		**Floor Area Density**		**Population Growth**		**Number of Houses per Unit Area**		**Average Settlement Area**	
	Rate	**Average Rate**	**Rate**	**Average Rate**	**Rate**	**Average Rate**	**Rate**	**Average Rate**	**Rate**	**Average Rate**	**Rate**	**Average Rate**
Unregulated Settlements	424		1.87		0.73		−12.43%		193		72	
Mass Housing Settlements	107	249	1.75	2.17	0.26	0.47	37.77%	10.76%	131	197	120	97
Apartment Settlements	345		3.87		0.77		-25.80%		391		89	
Detached Apartment Settlements	206		1.83		0.55		12.51%		201		88	

4.1.1. Floor Area Ratio in Settlement Area (Figure 20)

Apartment settlements: the highest floor area density.

Unregulated settlements and detached apartment settlements: these follow apartment settlements in terms of floor area density.

Mass housing areas: the lowest floor area usage rate.

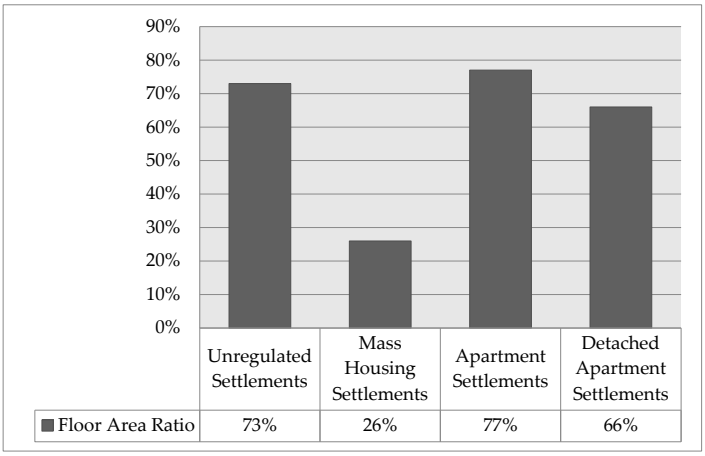


Figure 20. Floor area ratio in settlement area.

4.1.2. Average Settlement Area

According to this study conducted on nine neighborhoods and 1022 houses in Figure 21, it can be observed that the unit settlement areas in mass housing areas are higher compared to other settlement patterns. Figure 21 indicates that the average lowest settlement area size occurs in unregulated settlements.

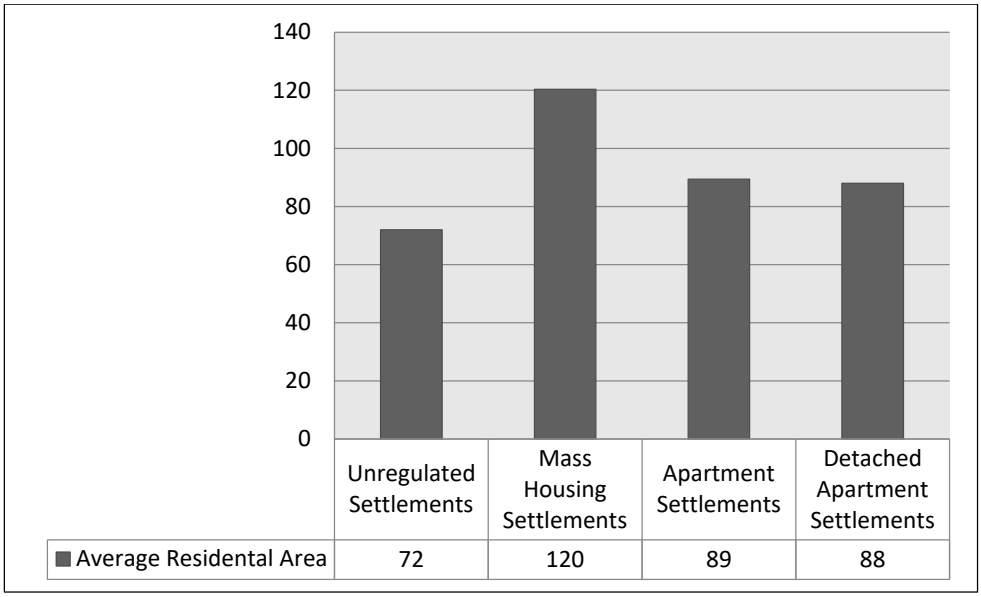


Figure 21. Average settlement area.

Based on the analysis, the average settlement area sizes in unregulated settlements, apartment settlements, and detached settlement areas with contiguous building patterns are between 84 and 89 square meters. However, in mass housing areas with separated building patterns, this value is 120 square meters.

This study identified four different settlement area types, determining that the total unregulated settlement area is 125 hectares, the mass housing area is 486 hectares, the apartment settlement area is 29 hectares, and the detached apartment settlement area is 47 hectares. According to the 2023 Address-Based Population Registration System (ADNKS) data, 33,919 people live in unregulated settlement areas, 52,178 people in mass housing areas, 11,739 people in apartment areas, and 9705 people in detached settlement areas. Consequently, the areas with the lowest population density are mass housing areas with 107 people per hectare. These are followed by detached settlement areas with 206 people per hectare, unregulated settlement areas with 272 people per hectare, and apartment settlements with 409 people per hectare, which have the highest population density (Figure 22). According to Table 2, it is observed that the total settlement area sizes in unregulated, mass housing, and detached apartment areas are quite similar (the number of houses per unit area $\times$ average settlement area). This suggests that the difference in population density between unregulated and mass housing areas stems from the average household size.

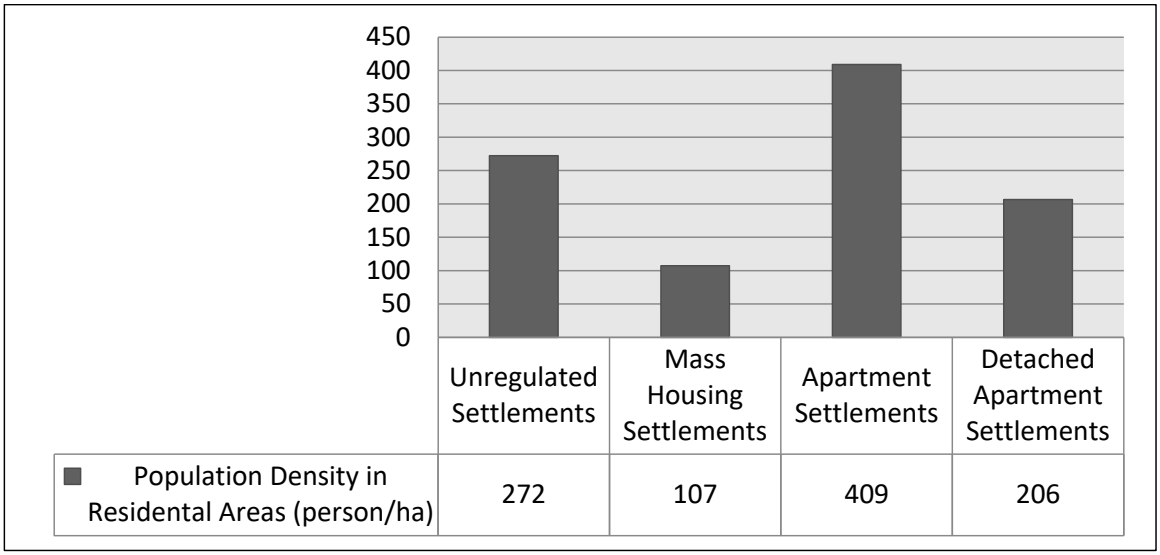


Figure 22. Population density according to settlement area types (person/ha).

4.1.3. Building Density in Settlement Areas

According to Figure 23, apartment settlements have the highest density with a value of 3.87 in the study area. The building densities of mass housing settlements, unregulated settlements, and detached apartment settlements are very close to each other, with values of 1.75, 1.83, and 1, respectively.

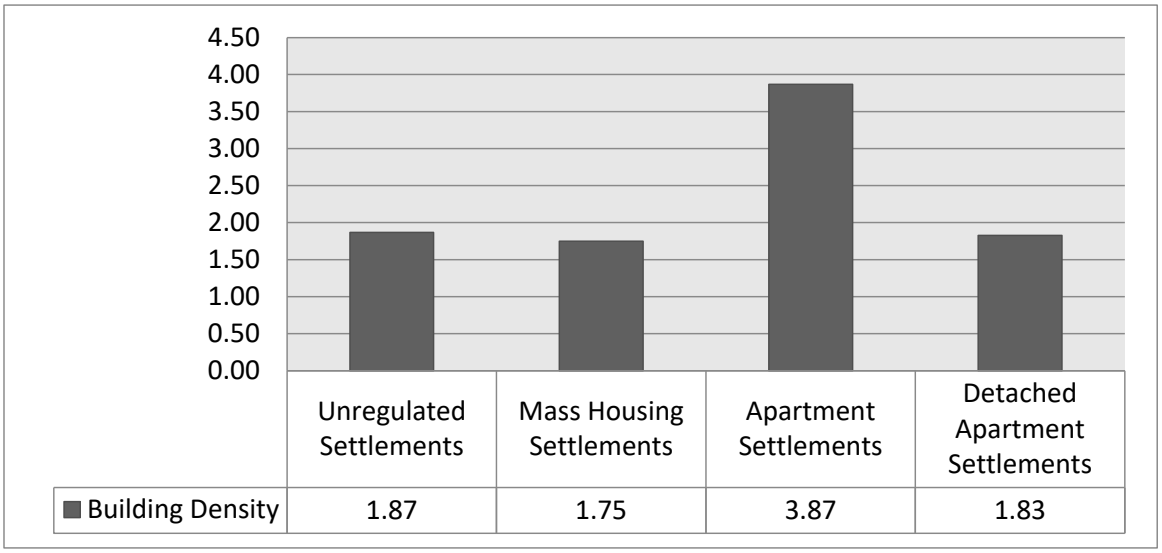


Figure 23. Building densities in settlement areas.

4.1.4. Settlement Building Density

Apartment settlements have the highest number of housing units per unit area, with 391 units per hectare. In unregulated and detached apartment settlements, this value is 193 units per hectare and 201 units per hectare, respectively. Mass housing areas have the lowest number of units per unit area, with 131 units per hectare (Figure 24). These data show that mass housing settlements have the lowest values in terms of population, building density, and the number of housing units per unit area.

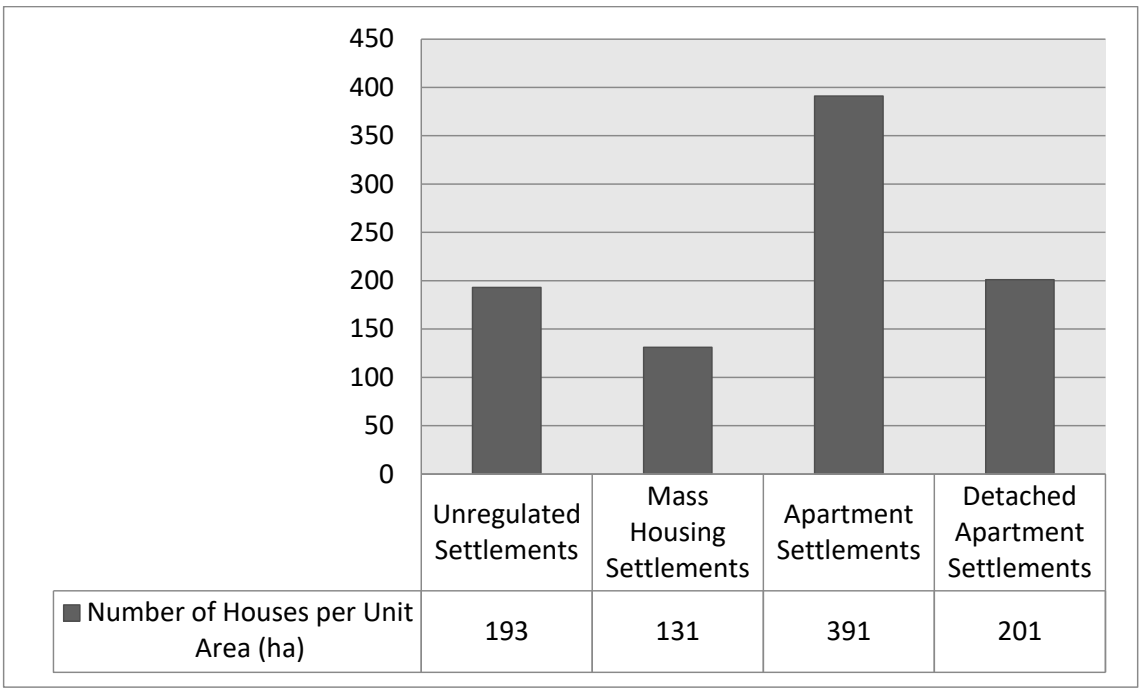


Figure 24. Number of houses per unit area.

Detached housing settlements, despite having lower floor and building densities and larger average settlement areas compared to unregulated settlements, accommodate more housing units per unit area than apartment settlements. The development of unregulated housing settlements was completed after 2004, and it is expected that these areas will be reorganized through urban transformation applications into mass housing, apartment, detached housing, or mixed-use settlement areas. Considering the population movements in these settlements post-2004, it is predicted that the population decline will cease. This indicates that, assuming population density remains above the general average and the average settlement area is at its lowest, if these areas are re-evaluated for residential use, building density and, consequently, population density will increase.

Apartment settlements have the highest floor area, building density, population density, and number of housing units per unit area among all settlement types. These settlements were established before 2004 and have experienced a continuous population decline, except between 2008 and 2011, from 2007 to 2023, becoming the most densely populated areas.

Unregulated settlements have approximately 50% of the building density and the number of housing units per unit area compared to apartment settlements, while possessing around 67% of the population density, making them denser than apartment settlements.

Detached housing settlements have similar population and building density values to unregulated settlements but have lower population density due to the larger size of housing units. Additionally, detached apartment settlements have lower floor area usage. Therefore, these two areas differ in terms of density based on the size ratio of average housing units.

In legal settlements, population density and building density tend to parallel each other, while, in unregulated settlement areas, population density and building density occur inversely (Figure 25).

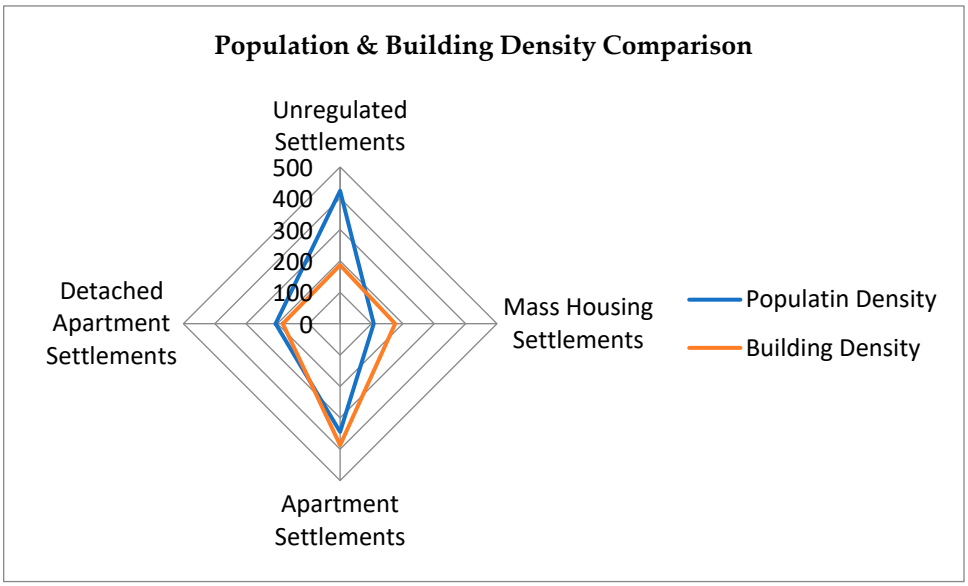


Figure 25. Population and building density comparison.

Indeed, while a balance between building density and floor area can be found in general settlement areas, this balance is disrupted in apartment settlements due to the high building density. Apartment settlements offer more floors and tightly packed buildings, resulting in denser construction. This causes the building density to be higher compared to general settlement areas, thus disturbing the equilibrium (Figure 26).

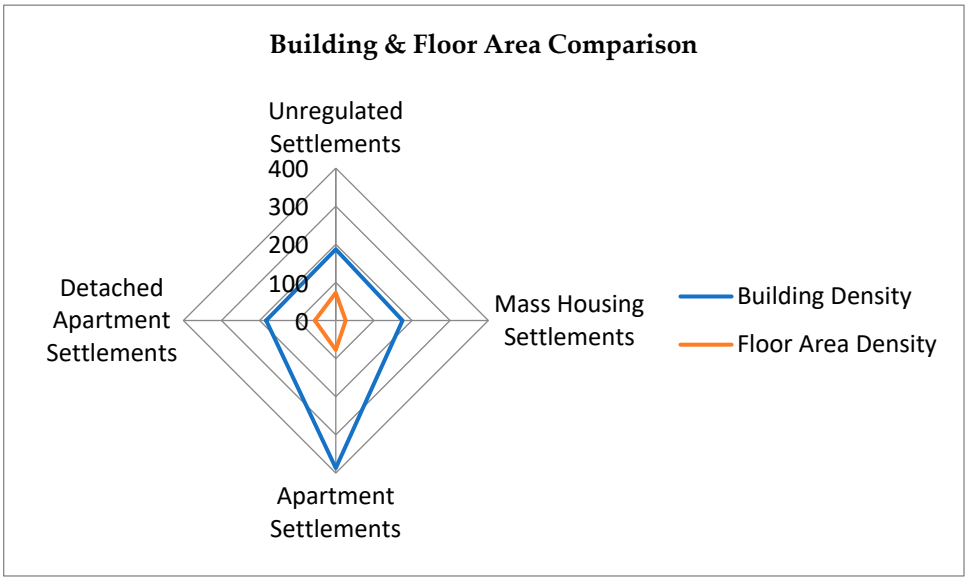


Figure 26. Floor Area and building density comparison.

In all settlement areas, the ratio of building density to the number of housing units per unit area has occurred in parallel. However, in apartment settlements, the number of housing units per unit area and building density are at higher levels.

Additionally, while most areas maintain this balance, apartment settlements stand out with their higher density of both buildings and housing units, leading to a significantly more compact living environment (Figure 27).

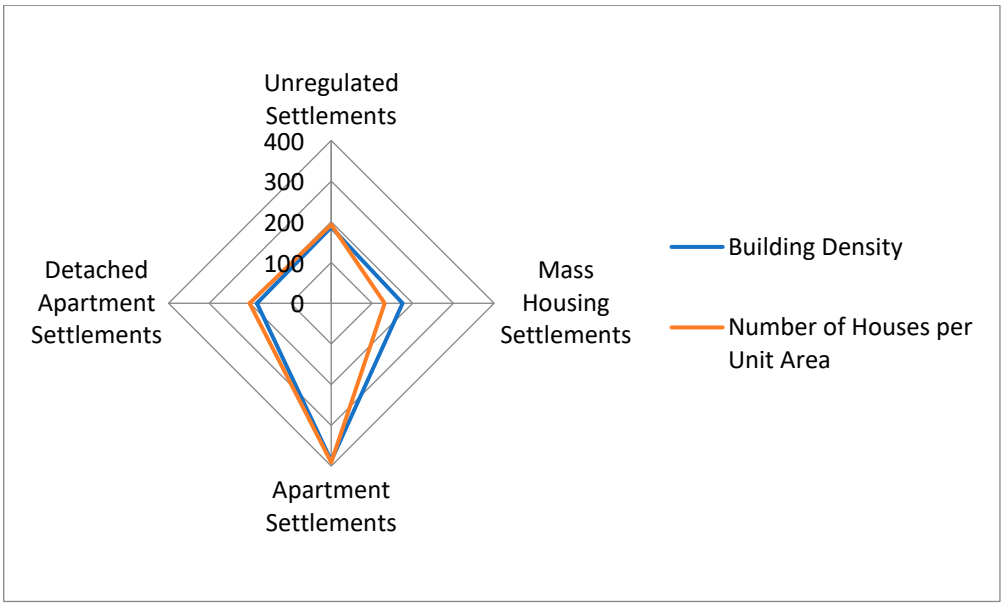


Figure 27. Building density and number of houses per unit area.

In settlement areas, a generally balanced relationship between population density, building density, and the number of housing units per unit area has been observed. However, in unregulated areas, high population density has disrupted this balance. In these unregulated settlements, while building density and the number of housing units remain at a certain level, population density has increased, thereby disturbing the overall balance in settlement areas (Figure 28).

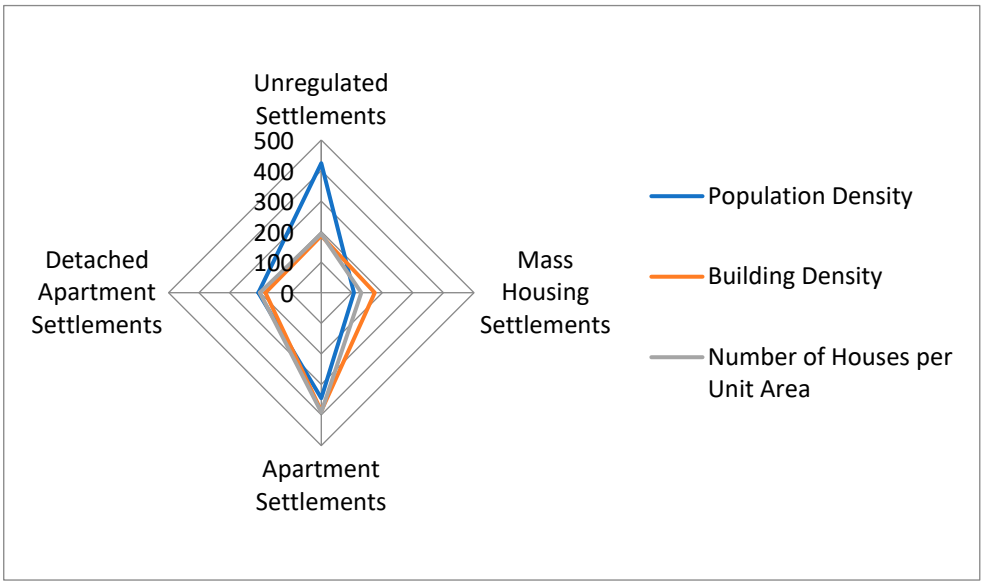


Figure 28. Population density, building density and number of houses per unit area.

In apartment settlements, population and building density have reached the highest levels. However, despite the high building density, it has been observed that the population in these areas is decreasing. This indicates that, although the existing infrastructure is being used beyond its capacity, the population is still declining. On the other hand, mass housing areas exhibit the highest population growth rates. This suggests that mass housing areas are accommodating more people, and their popularity is increasing (Figure 29).

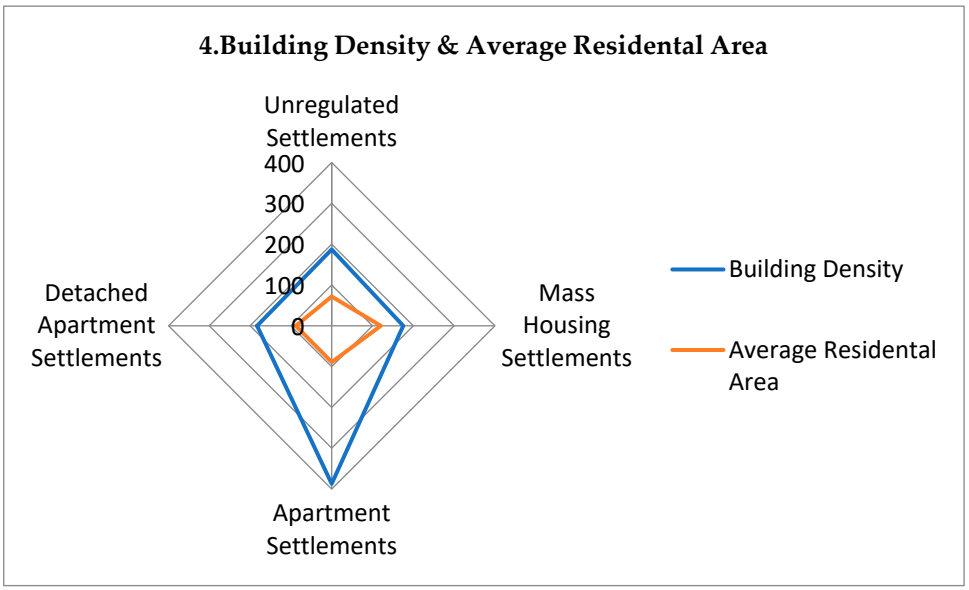


Figure 29. Average Residental Area and building density.

In unregulated settlement areas, population density is higher compared to building density. On the other hand, in apartment settlements, both population and building density are at high levels. In mass housing areas, building density is higher in relation to population density, while, in detached apartment settlements, both values are balanced (Figure 30).

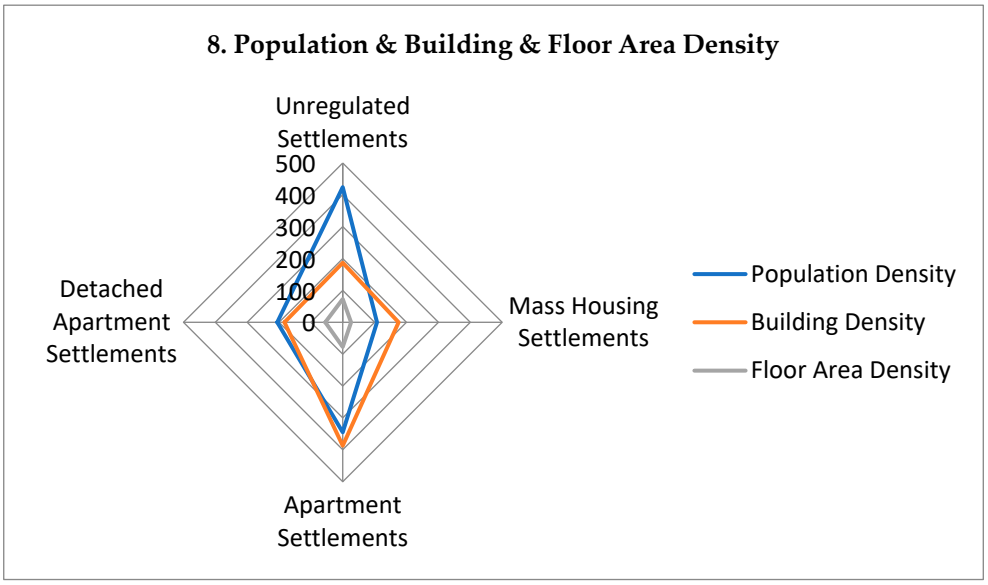


Figure 30. Population density, building density and floor area density.

According to this figure, areas with high population density also have a high floor area usage ratio. This indicates that buildings in densely populated regions have larger floor areas.

4.2. Conclusions

This study evaluated four different types of housing developments in Bursa Osmangazi from the 1960s to the present. This article aims to optimize the use of the city's existing settlement areas, considering urban infrastructure, transportation, and environmental degradation. One of the primary goals of this article is to maintain the existing population in urban transformation areas.

Based on this study, four different housing settlement types developed in Bursa Osmangazi since the 1960s have been evaluated. Additionally, this article aims to optimize the use of the city's current settlement areas by considering aspects such as urban infrastructure, transportation, and environmental degradation. One of the main objectives of this article is to retain the existing population in urban transformation areas.

4.2.1. Population Growth and Building Density (1960–2004)

In settlement areas developed between 1960 and 2004, population growth has halted, and, as building density increases, the population declines more rapidly. According to current legal conditions, these areas have reached the end of their economic life.

4.2.2. Household Size

According to TÜİK data, the average household size in Bursa has decreased from 3.70 to 3.14 over the past 16 years, indicating a population decline of approximately 15.13%. While the population has decreased in areas developed before 2004, it has increased in areas developed after 2004. This cannot be explained solely by the decrease in average household size, suggesting a population shift from old housing areas to new settlement areas.

4.2.3. Irregular Settlement Areas

In irregular settlement areas, building and population densities are within legal "high density" values. However, the ground area density is above the average. The buildings in these areas have been constructed illegally, and there are no projects regarding the quality of the structures. Agricultural areas that have not lost their agricultural quality should be preserved, and the existing development should be reproduced.

Due to the insufficiency of social and technical facilities in these settlement areas, the ground area should be reduced, and social and technical areas should be increased. Building and population densities can be increased within high-density limits. For those who do not prefer to continue residing in the area, alternative solutions should be created. Mixed functions should be established to form an urban sub-region due to its high-density nature. Additionally, new textures should be shaped considering the geomorphological characteristics and seismicity measures of the settlement areas.

4.2.4. Mass Housing Areas

In mass housing areas, population density is significantly lower than building density. The density of structures in these areas can be increased up to the "high density" limits. However, because the average housing area is above the general average, population density is within "medium density" limits. These are legal settlement areas with projects related to the quality of the buildings. Therefore, the structures in these settlement areas should be preserved and strengthened.

4.2.5. Apartment Settlement Areas

In apartment settlement areas, building density is at the "very-high-density" residential values. Meanwhile, population density is within "high-density" limits. The number of housing units per unit area is significantly higher than other settlement areas, and the structures in these areas have been legally constructed.

4.2.6. Necessary Housing Units

According to current data, the required number of housing units relative to the population is calculated as follows: 345 (persons/ha)/3.14 (household size) = 109.87 (units/ha) However, these areas have an average of 391 independent housing units/ha. This suggests

that household sizes in these areas are relatively small or that there is a high number of unused housing units.

4.2.7. Legal Settlements and Transformation

Firstly, as these areas are legal settlements, it is possible to extend the lifespan of low-density apartment settlements by strengthening them without complete demolition. Therefore, special legal regulations should be enacted for the transformation of these areas. Two different approaches can be taken for the transformation processes in these areas:

Strengthening and Improvement: By strengthening existing structures and improving living conditions, the lifespan of these areas can be extended. This is particularly applicable to low-density apartment settlements.

Conversion to Mixed-Use Areas: To reduce density and provide financing, these areas can be converted into mixed-use areas. This involves creating spaces that combine commercial and residential functions.

In both cases, historical buildings should be preserved and repurposed to maintain their functionality. By doing so, the historical value of the area is preserved while meeting modern needs.

5. Discussion

In this article, by comparing the densities in urban housing settlements analyzed, the positive and negative aspects of existing textures in the redevelopment process of urban housing textures are addressed. The aim is to determine the density differences in a potential urban transformation plan, to make adjustments across the urban texture, to use existing settlement areas more efficiently, to prevent new urban sprawl, and to create more livable, sustainable urban textures. However, the approach to density in urban housing areas should also be evaluated with elements such as social interactions, commercial vitality, and the use of social spaces, as well as technical requirements such as infrastructure and transportation. This means associating different scales with different densities, which is a matter of scale. Although the issue of scale was not discussed in this study, general evaluations of densities were made considering the average values of this study area.

In this context, there are many factors to consider regarding density and scale for urban transformation projects to be successful. Disproportionate population and building densities were observed in areas developed between 1960 and 2004. Despite the city's population growth, the decrease in population in these areas is a significant indicator that these areas have begun to lose their function.

Furthermore, in Turkey, especially within the boundaries of Bursa Osmangazi, the expected severe earthquake risk and its potential social and economic consequences increase the urgency for renewal/transformation in these areas. In this regard, these areas need to be prioritized both publicly and sectorally, and a rapid decision-making process should be ensured.

The urgent transformation of these regions under earthquake risk is crucial for creating both safe and sustainable urban areas. The effective and swift management of renewal and transformation processes is of great importance for preventing possible disasters and enhancing the quality of urban life.

Finally, considering that urban population and growth rates are expected to continue in countries that have not yet completed the industrialization process, it is anticipated that settlement areas will continue to develop rapidly through both legal and illegal methods. In a world where natural disasters such as earthquakes, floods, and fires frequently occur, it has been observed that low-quality settlement areas developed during the industrialization process suffer significant destruction. It is vital to produce more livable, healthy, and

multifunctional urban sections and ensure this production and organization are carried out quickly and at the lowest cost.

In this context, urban renewal processes should aim to renovate existing urban areas and make new settlement areas more sustainable and resilient through proper planning and implementation. Different densities and scales should be associated in these processes, considering social interactions and technical requirements. This approach will help create urban areas that are not only more functional but also capable of withstanding various challenges, ensuring a higher quality of urban life.

Urban Transformation Principles

In urban transformation projects, by comparing the building and population densities of existing settlement areas and adopting the principle of implementing urban transformation on an urban scale, the following objectives can be achieved:

Address Transformation on an Urban Scale: handle the transformation process of settlement areas on an urban scale to balance density.

Integrate Idle Spaces: include idle spaces resulting from the irregular formation of existing buildings into urban density.

Comprehensive Density Plan: involve real estate developers and financial resources in the redevelopment process of existing settlement areas with a comprehensive density plan, considering future population projections of cities.

Increase Housing Accessibility: regulate the current housing stock during the urban transformation process to increase accessibility to housing.

Protect Property Rights and Resolve Issues: address legal and technical issues while protecting property rights.

Prevent Disaster Costs: prevent the human, economic, and environmental costs of potential natural disasters.

Ensure Sustainability: achieve economic, social, and environmental sustainability in the development of cities.

Create Inclusive Cities: reach the goal of "cities for all" as defined in the New Urban Agenda adopted at the UN HABITAT III Conference, which includes equal rights to human settlements, adequate housing, and accessible, functional, physical, and social systems, encompassing and spatially integrating all segments of society. [18]

Meet Sustainable Development Goals: Contribute to the goal of ensuring access to adequate, safe, and affordable housing and basic services for all by 2030 and upgrading slums, as stated in the 2030 Sustainable Development Goals adopted at the 2015 UN Sustainable Development Summit. Also, contribute to the goal of significantly reducing economic, physical, social, cultural, and environmental losses caused by disasters by enhancing disaster preparedness and ensuring effective responses, as outlined in the 2015–2030 Sendai Framework for Disaster Risk Reduction.

In this context, it is emphasized that urban transformation processes should include not only the renovation of existing settlement areas but also the relocation of the population to new areas. This approach is crucial for creating more sustainable, resilient, and livable cities.

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