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Research Article

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Resilient Urban Form: A Case Study on Denizli, Gaziantep and Muğla

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Abstract

Purpose

This study identifies whether the hierarchy, development type, and city size have a crucial effect on resilience in ecological terms. Is there a desirable optimum urban form for resilience? The study aims to answer this question by comparing different types of macroform and density of some selected cities in Turkey.

Design/Methodology/Approach

Denizli, Muğla, and Gaziantep provinces are selected according to the comparability of their population size and urban forms in relation to the greenhouse gas emissions of each city. A retrospective causal comparison method was used in the study. Using the Corine Land Cover Classes program, the change of the artificial surfaces and the city structure between 1990 and 2018 were mapped and detailed graphics were created.

Findings

Findings show that greenhouse gas (GHG) emissions originating from road transport in Muğla, which has a multi-centered form, were the highest. The surprising result is that Gaziantep has lower GHG emission rate than Denizli although its population is twice the latter. The emission rates of the housing and services sectors were compared with the household size. Gaziantep having the largest household size has the lowest emission rate in this sector. The paper suggests that a hierarchical urban system structure is essential for the resilience of the city to be able to organize itself more effectively, adapt to external changes faster, and create a stronger and more complex structure. City size is an important criterion for low infrastructure cost, efficient use of resources, and capacity to access capital of all kinds. Yet, this criterion may differ in the resilience of the city depending on several factors such as population, area size, and distribution of various urban functions. The development type, on the other hand, is highly effective on GHG emissions as the monocentric cities generate fewer emissions than the polycentric cities.

Research Limitations/Implications

The GHG reports created for the case areas consisted of different years and different analysis units. This limits the sectors to which cities can be compared.

Originality/Value

This article is a detailed and original study in terms of evaluating the resilience of Turkish cities with different morphologies.

Keywords: *Urban resilience, urban forms, hierarchy, city size, development type*

INTRODUCTION

Cities as socio-ecological systems are faced with various stress factors such as climate change, population growth, and depletion of resources. New solutions are constantly being sought for these inevitable threats. Among many studies on this subject, sustainability, risk management, and resilience are the most discussed themes. However, these themes are not completely different from each other. The studies on a sustainable environment also include the results of resilience (Yalçıner Ercoşkun, 2012). So why has the shift from sustainability to resilience been increasing in recent years? The concept of resilience, from a perspective accepting that the world is at risk; offers quick solutions against vulnerabilities and uncertainties with adaptation and flexibility steps (Hoffman, 2014).

As levels of urbanization increased, global carbon emissions from the combustion of fossil fuels increased by almost fivefold between 1950 and 2005 (Mayer, et al., 2017). Cities account for 60% to 80% of energy consumption and 70% of anthropogenic greenhouse gas emissions (UN-Habitat, 2016). Greenhouse gas emissions are strongly linked to the energy use and waste produced by a city (Seto, et al., 2014). In an effective fight against climate change, an increase in the urbanization level can be considered as an opportunity in a way.

According to the Intergovernmental Panel on Climate Change (IPCC), urban concentrations on almost all continents will be subject to a temperature increase more than 1.5°C above pre-industrial temperature by 2050 (Revi, et al., 2014). The frequency of extreme weather events is also expected to rise, thereby increasing the risk of morbidity and mortality (Rosenzweig et al., 2015). Over the 80% of urbanized areas are under threat of natural disasters. Also, 89% of cities are economically vulnerable to at least one natural disaster (UNHabitat, 2016).

Considering all these facts, it becomes essential to formulate policies to build resilient cities. However, there is still no comprehensive evaluation system. This study aims to find the relations between urban form and resilience. This relation has been examined through the sectoral distribution of carbon dioxide emissions in three cities. Denizli, Gaziantep and Muğla provinces are the case areas and the research was conducted at macro level. In the following headings, the sectoral distribution of carbon dioxide emissions in these cities were evaluated over the categories of hierarchy, development type and city size. These sectors are categorized as road transport, housing and service buildings, and waste.

RESILIENT CONCEPT

The term of resilience originated in the field of ecology in the 1970s, and is defined as the capacity of a system, when faced with disturbance or disruption and maintain or recover its functions (ARUP, 2014). Recently, the concept of resilience has gained a remarkable importance in several disciplines. Actually, the increasing interest on resilience concept derives

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from the systemic and interlocking risk such as economic instability, climate change, and recently Covid-19 and health crisis (Scott, 2021).
The notion is based on the idea that uncertainty is inevitable and thus impossible to plan for every outcome (Ajibade, 2017). Instead, resilient systems through the capacity for self-determination (Folke, 2006) or social learning are likely to respond to changing conditions, even if that change is unpredictable.

Resilience in Urban Studies

Especially in the last decade, urban resilience has gained recognition and been located in global development plans. Urban resilience play a key role on the COP21 Paris Agreement on Climate Change, the Sendai Framework on Disaster Risk Reduction, and the New Urban Agenda, related to climate change, natural disaster, and urban development. Also, it is included in UN Agenda 2030 as one of its 17 Sustainable Development Goals (SDGs) (UN, 2015).
The concept of resilience can be used for cities with a complex structure that is constantly changing and adapting to conditions. In consequence of several debates in urban literature, the term of "urban resilience" is defined as the ability to maintain, adapt or transform the urban system that constitutes all socio-ecological and socio-technical networks in the face of uncertainty and change (Pickett et al., 2004; Brand and Jax, 2007; Meerow, Newell and Stults, 2016; Altun and Tezer, 2019). Salat and Bourdic give some examples from the disastrous experience of cities and define urban resilience as; " The capacity to survive disasters and even to rise out of its ashes, like Lisbon after the 1755 earthquake, London after the Great Fire in 1666, Kyoto after the fires in the Middle Ages, Tokyo after the 1923 earthquake, is what we call urban resilience – a complex concept related to the permanence of a memory at once social, symbolic and material". Also they criticise the modern city structures as they are more fragile because of disordered uniformity of their urban fabric, the lack of hierarchical structure, environmental impact of the construction, inefficient use of resources, and higher exposure to risks (Salat and Bourdic, 2012, p. 56-57).

Debates on Urban Resilience Theory

Resilience theory is mainly divided into two parts; equilibrium approach and evolutionary approach.
Equilibrium resilience generally refers to engineering disciplines. This approach suggests that a resilient system absorbs or accommodates the shocks and disturbance but does not change the system (Holling, 1973). The goal is to bounce back to the pre-disaster state in a rapid fashion. On the other hand, the normality of absorbing or accommodating the disturbance without any change in the system is questioned by academic circles. In such a case, there is a possibility that the normal system poses a risk (Davidson, 2010).

Evolutionary approach, contrary to equilibrium- based one, rejects to turn back to the normal and highlights the adaptation, reform, and transformation processes. This approach emerges from evolutionary economic geography discipline. The main emphasis in this theme is that development can occur in multiple pathways, not just a single path. In short, the important point in this approach is that social systems adapt to change or transform the system by developing alternative ways (Davidson, 2010).

This approach also introduces threshold ideas where a change in a variable can drive the system to a tipping point and cause the situation to change. This reorganization is a phase of what is known as the "adaptive cycle", a term used to show how complex systems go through stages of growth, expansion, collapse, and regeneration (Folke et al., 2010). These adaptive cycles can be nested by interacting between scales which is a dynamic known as "panarchy".

There are some critiques about evolutionary based approach in literature. Scott maintains that transitions do not always bring about positive outcomes. Moreover, he emphasizes the necessity of finding out which local/regional interest prevents the transition (Scott, 2021).

Urban resilience researchers have developed the idea of tradeoffs to show that maintaining resilience in one area can be at the expense of another (Bahadur & Tanner, 2014). Such is the case where preventive infrastructure is deployed to protect economically valuable urban cores from flooding at the expense of surrounding low-income settlements (Marks and Lebel, 2016). While accepting the issues of equality and trade-off, examining the contextual factors that create situations of inequality, in other words, the political economy of urban resilience is a weakness of the literature (Béné et al., 2018).

Another weakness of the resilience literature is its neglect towards “vulnerability”. Faulkner et al. propose a model that highlights the relationship between vulnerability and resilience in order to analyze how a place responds to shocks and crises (2020). In this model, the key components are exposure (pre-existing attributes), sensitivity (negative response), capacity of response (pre-existing attributes), and adaptive capacity (positive response). The holistic vulnerability – resilience model presents the posibility of a region as both vulnerable and resilient at the same time. Additionally, it elucidates the reason why some places are affected from exogenous shocks less while others appear more vulnerable. The components of exposure and capacity of response may reflect the characteristics of historic cycles of shocks. Most recent shocks, on the other hand, are analyzed by the components of sensitivity and adaptive capacity. Identifying pre-shock trajectories and determining what circumstances lead to these trajectories is important for assessing the resilience/vulnerability of the region. This is a progresive model because it handles the urban system both negative and positive responses, does not ignore the vulnerability, and offers a comprehensive method.

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Resilient Urban Form and Indicators at Macro Scale

Urban patterns in cities are components that affect city life in social, economic and ecological dimensions for decades or even centuries. For this reason, urban form is of great importance for a resilient city. There are some studies about desirable urban form and its relation with energy consumption. These show that desirable urban form consume 50-60% less energy than the others (Salat and Bourdic, 2012).

Urban form is a spatial model that shapes by human activities in space and time (Sharifi, 2019). Such activities result in the formation and transformation of various physical elements. Analyzing urban form can be done in three different and interconnected scales: macro, meso, and micro levels (Fang, Wang and Li, 2015).

Resilient urban form can be defined as a system nested in a network of interconnected spatial and socio-ecological systems characterized by evolutionary spatio-temporal dynamics, and as socio-economic and environmental conditions whose integrity, habitability, and functionality are constantly changing (Sharifi and Yamagata, 2018).

The prominent indicators of resilient urban form at macro scale in literature can be listed as follows; hierarchy, city size, and development type.

Hierarchy: A hierarchical order can be found in many natural and social systems and it is necessary for urban resilience. In a hierarchical urban system structure, an inverse force formation is observed in the connection between the size and frequency of urban factors and features (Sharifi, 2019). According to Salat (2017), scale-free cities (in contrast to mono-scale) supported by a hierarchical structure are more resilient than mono-scale structures. Such a hierarchy of scale allows the city to organize itself and adapt more quickly to external changes (Salat, 2017). In cities having hierarchical structure, small-scale components gradually evolve and connect to the upper scales and create a complex and powerful form. However, there are concerns about weakening this form due to rapid urbanization, rent and speculation in Turkish cities.

Additionally, the relation between modularity and connectivity is also important. The balance between them may differ for each region. In some cases, it may be better to strengthen existing center-to-center links in one region for resiliency, while strengthening the relative autonomy of each center in another region. (Allan et al. 2013).

City size: Population and surface area are the two elements that determine city size. However, the link between surface area and population may not always be strong. The relation between a city's size and resiliency can vary. At first glance, larger cities are likely to be exposed to potential risks with more people than others. This is likely for cities without plans and preparedness for action. On the other hand, there are discussions that large-scale cities are more resilient in terms of economies of scale and efficient use of resources. Cities in Europe are examples of this situation. They resist economic crises more and recover faster. The reasons are listed as the lower infrastructure costs, the

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efficient use of resources, and their capacity to access natural and physical capital (Louf and Barthelemy, 2014). However, this economic prosperity and endurance may have been gained by ignoring environmental resilience.

Studies have revealed conflicting results on the relationship between city size, energy consumption, and CO2 emissions. Studies conducted in England show that a big city structure causes low energy consumption in transportation, while studies conducted in India have shown that there is a direct relation between city size and energy consumption. The studies conducted in the United States of America have yielded results in the same direction as the UK (Sharifi, 2019). In a study on 30 metropolitan cities in China, it was determined that as the urban area grows, CO2 emissions also increase (Fang et al. 2015). On the other hand, the simulation analysis conducted by Larson and Yezer (2015) examined the relationship between the increase in city size and income level. Accordingly, if the city size grows in consequence of the increase in the income level, the energy consumption - city size relation remains the same. However, while the income level is constant and city size continuous to develop (under some situations such high density, small housing units, high housing rents, short distance to work), energy saving is achieved. Thus, the criteria that clarify whether the expansion of the urban area will benefit the environment are the urban growth model and the distribution of urban activities (Lee and Lee, 2014). In this respect, mixed land use and comprehensive transportation strategies are the tools to prevent the increasing city size from resulting in urban sprawl and automobile addiction (Louf and Barthelemy, 2014).

Development Type is one of the elements of determining the resilience of a city. In this respect, compactness is the subject of this title. To determine the compactness, density analysis is required. Many studies show that compact forms provide convenience in terms of resilience to hazards, as many facilities are accessible. However, development types such as compactness and poly-centric urban forms are not sufficient alone for the urban resilience. Modularity and connectivity are also important. Each center should have internal integrity that can meet the needs in times of crisis and afterward, and should keep strong connections with other centers (Allan et al., 2013).

In a case study in Australia, it has been shown that regions with high density and diversity in the built environment have a positive effect on post-disaster recovery capacity. On the other hand, in areas outside the urban area, it has been observed that the most important factor for disaster resilience is the level of income rather than the built environment and density. In these regions, land use mix and building type diversity have a weak effect on recovery. However, the recovery process in low-population with the high-income suburbs was not as rapid as medium-density with middle-income suburbs (e.g. Balmoral, Bulimba, Paddington). (Alizadeh, Irajifar, & Sipe, 2016). So, there is a sensitive line between density and income level. If the income level rises too high and

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the density decreases, resilience may decrease. If the density rises too high and the income level decreases, the region may be getting fragile. Therefore, keeping the two sides balanced is an important and difficult task.

A study conducted in Alberta, Canada showed that mixed-use settlements has the potential to significantly reduce daily car-oriented travel (Hachem, 2016). Accordingly, greenhouse gas emission rates from transportation are lower. For residential neighborhoods, the effect of distance from the central business district (CBD) is very important. The greenhouse gas emission rate of a settlement 30 km from the CBD is 40% higher than the place located 5 km away from the CBD.

RESEARCH METHOD

A retrospective causal comparison method was used in the study. In order to analyze the resilience of the city on a macro scale, Sharifi argues that 5 indicators must be evaluated (2019). These are scale hierarchy, city size, development type, degree of clustering, and landscape/habitat connectivity. In this study, the first three indicators were evaluated due to collected data. Three different Turkish cities were determined as study areas. These cities show similarities and differences that can be compared with each other in terms of hierarchical structure, city size, and development type. Greenhouse gas inventory reports of these cities prepared previously according to the IPCC criteria were used. The report years were considered for using the data throughout the study. Cities were compared based on their carbon dioxide equivalent consumption (CO2e) in the transportation, residential and service buildings and waste sectors. Thus, the resiliency of urban forms could be evaluated depending on their vulnerability. Graphics were produced for the comparison. During the study, additional analyzes were made in order to interpret some of the results. Income level, average household size and socio-economic development levels of the districts were considered (SEGE, 2013; 2019). Data about income level was deemed necessary to find the relationship between arbitrary choices in the transportation sector and the change in CO2e amount. Data on average household size was required to reveal the relation between population density and CO2e. The datum of socio-economic development level of provinces and districts was needed to examine the hierarchical structure.

Using the Corine Land Cover Classes, the change of the artificial surfaces (classes of industrial commercial and transport units, mine, dump and construction sites, artificial, non-agricultural vegetated areas) and city structure between 1990 and 2018 were mapped in ArcGIS, and detailed graphics were created. The effect of these differences on urban resilience was measured according to these classes.

CASE STUDY ON DENIZLI, GAZIANTEP AND MUĞLA

According to the report of UNFCCC (2020) about "National greenhouse gas inventory data for the period 1990 – 2018", Turkey ranks 1st among

Annex I parties with an increase of 160.6 % GHG emissions. New Zealand is the second with an increase of 57.2%. This disturbing table shows that the need for emergency regulations in climate policy in Turkey. This study can be an important resource for understanding current problems in cities and generating solutions.

As shown in Table 1, these three cities have been selected because the resilience indicators of them have similarities and differences. Gaziantep has a monocentric urban form and its population is 1.931.836 (2015, report year). Denizli has a monocentric urban form and its population is 993.442 (2016, report year). Muğla has a polycentric-linear urban form and its population: 866.665 (2013, report year). Gaziantep and Denizli show similar development type. However, Gaziantep's population is approximately twice of Denizli. Thus, comparison of these two cities will show the impact on the carbon emissions of the population. While Denizli and Muğla have approximately the same population, urban forms differ. Thus, the relationship of urban forms with GHG can be measured. Since Gaziantep and Muğla differ in terms of both population and city form, the effect of two different variables on GHG can be observed (Figure 1).

Table 1. Comparison of Provinces (TURKSTAT, 2021a) (This table created by the authors)

Indicator	**Denizli**	**Gaziantep**	**Muğla**
Scale of Hierarchy	Very large and very small size districts	Very large and very small size districts	Medium size districts
Development Type	Monocentric	Monocentric	Polycentric
City Size (Population)	993.442	1.931.836	866.665

Table 2 shows that each study area situates at different socio-economic development levels. Considering the socio-economic development ranking of the districts, there is a balanced and gradual distribution in the districts of Muğla and Denizli, however, the level difference between the districts of Gaziantep is quite high (SEGE 2019b; 2013). Detailed analysis of the districts was made under field studies.

Table 2. Socio-Economic Development Index of Provinces in Turkey (SEGE 2019b; 2013)

City	**2017**			**2011**		
	Ranking	**Index**	**Level**	**Ranking**	**Index**	**Level**
Muğla	8	1,175	1	8	1,04	1
Denizli	10	0,923	2	10	0,912	2
Gaziantep	30	0,250	3	30	0,267	3

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Figure 1. Provincial map of the study areas located in Turkey

In the study, the distribution of population densities of the cities, construction changes by years, population changes by years are indicated with maps and figures.
In the findings section, using the greenhouse gas inventory reports of the provinces, road transport, residential and service buildings, and waste factors were compared.

Denizli

The main economic activity of Denizli province is the industry sector (Provincial Directorate of Environment and Urbanism, 2016). According to the data from the “Research of Socio-Economic Development Ranking of Districts SEGE-2017, Denizli districts are mostly in the third level (2019). In this respect, there is a balance in the distribution of resources in the districts.

Population Density and Urbanization Process of Denizli Province

The population in 2016 is 993,442 inhabitants. Pamukkale and Merkezefendi districts, formerly central districts, constitute 63% of the total population of the province. The population of Pamukkale district is 347,444 and the population of Merkezefendi district is 287,852. The third highest district population is Çivril district with 60,721 people. As seen in Figure 2, there is a big difference between the central districts. Between 1990 and 2000, Denizli province, with a rate of 47%, was one of the cities with the fastest growing urban population in the country (TURKSTAT, 2021a).

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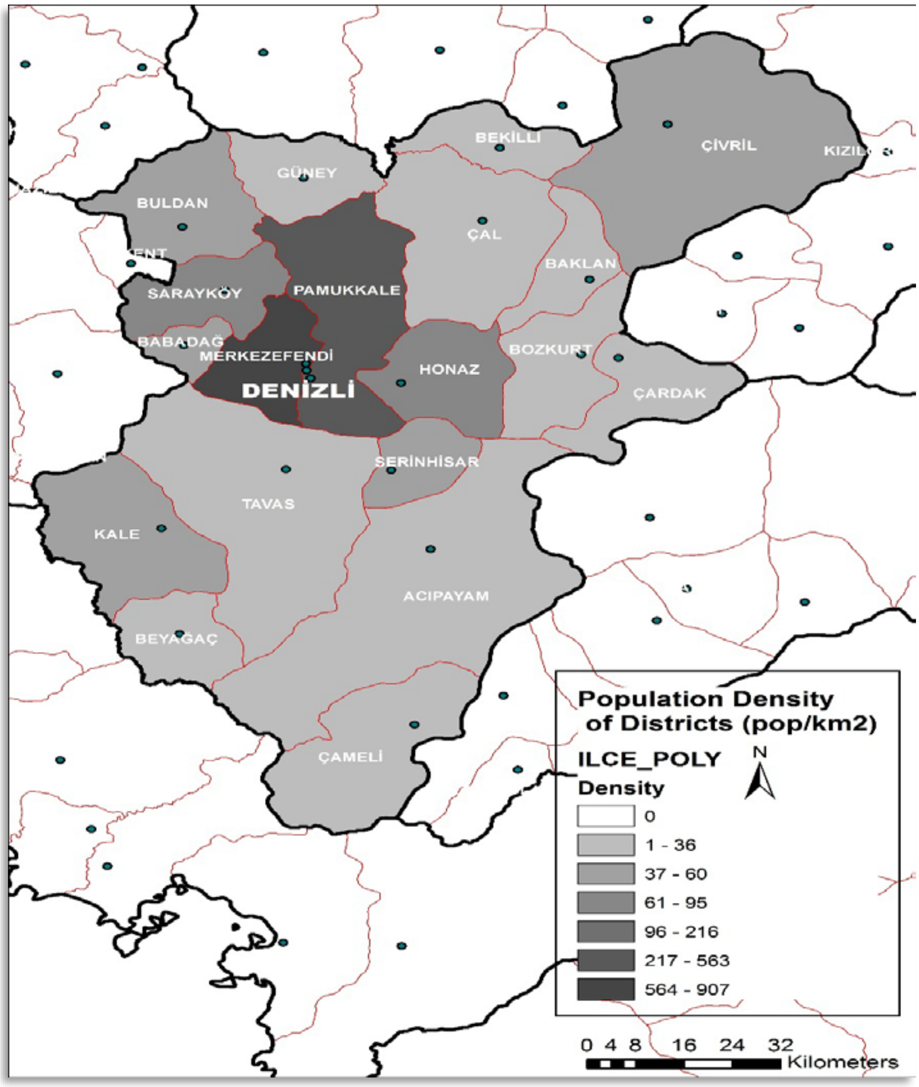

Figure 2. Population Density of Districts of Denizli Province in 2016 (This figure created by the authors, using the data of TURKSTAT, 2021a)

The change in the artificial areas and the population growth rate of Denizli province between 1990 and 2018 are given in Figure 3.

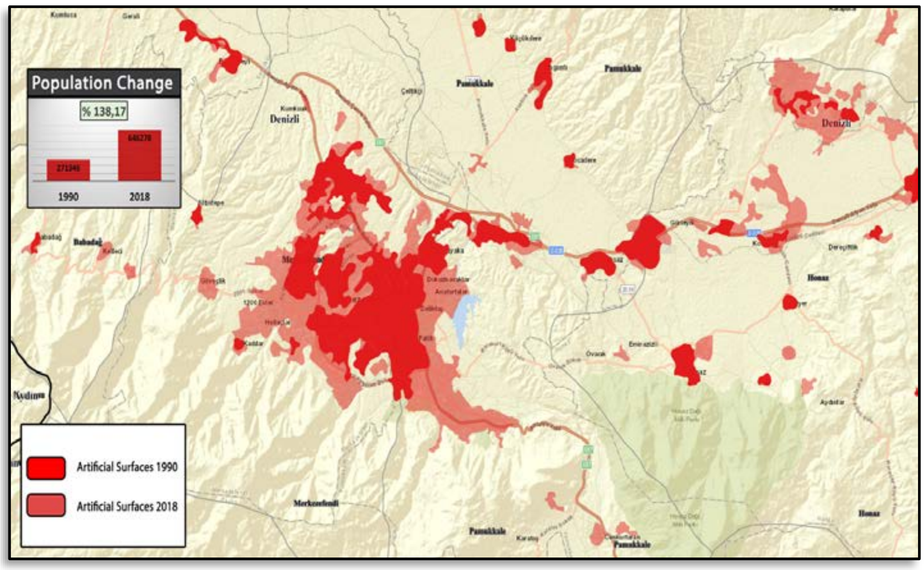

Figure 3. Changes in the artificial surfaces and population in Denizli between 1990 – 2018 (This figure created by the authors)

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As seen in the Figure 4 and 5, the change in the urban fabric between 1990 and 2018 is 38%. The increase in other artificial surfaces has increased 12 times during this period. Population growth is at the rate of 138%. While population growth is higher than urban fabric, it is considerably less than other artificial surfaces. When this change is compared with the energy consumption rate per capita, energy savings have been made in the province.

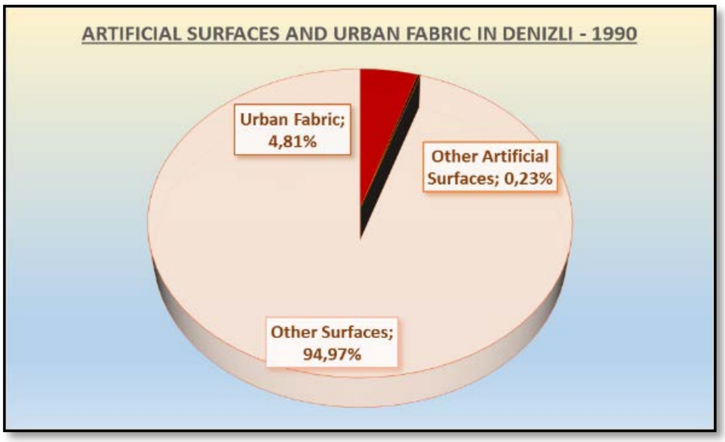

Figure 4. Artificial Surfaces and Urban Fabric in Denizli – 1990

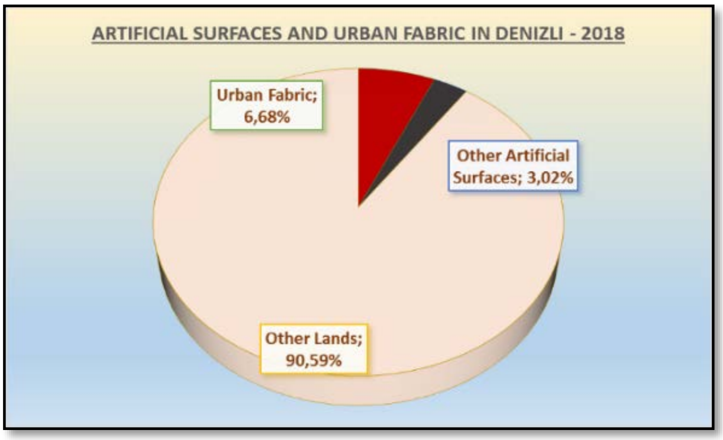

Figure 5. Artificial Surfaces and Urban Fabric in Denizli – 2018

Carbon Equivalent Emissions of Denizli Province

According to the results obtained with the IPCC approach, the total greenhouse gas emissions of Denizli province for 2016 were calculated as approximately 7.5 million tons of CO_2e. When this amount is compared to the population of Denizli in the same year (1,005,687), it means 7.5 tons of CO_2e per person. This result is above Turkey's average amount of emissions (6.3 tons CO_2e per person) for 2016. Total emissions of Denizli constitutes 1.5% of Turkey's total emissions in 2016 (Denizli Metropolitan Municipality, 2019).

Figure 6 shows that 43.8% of total emissions are based on fixed sources; 23.1% on transportation, 20.8% on industrial processes, 11.3% on agriculture and animal husbandry, and 1.0% on waste management. Almost three quarters of these emissions are caused by Scope 1 - Direct

Emissions and 22% from Scope 2 - Indirect Emissions. Emissions from residences, commercial/institutional buildings, manufacturing industry and construction, the energy industry, and agricultural activities were calculated within the scope of the fixed resources sector.

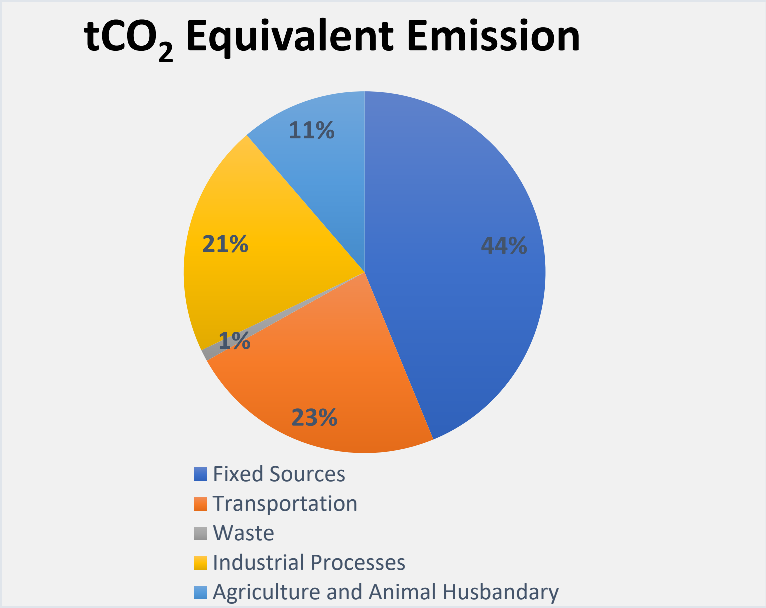

Figure 6. Greenhouse Gas Inventory Sectoral Distribution of Denizli

Denizli is a city that continues to grow. It is stated in TURKSTAT reports that the population of the province, which was 1 million in 2016, will reach up to 1.2 million in 2030. A significant increase in greenhouse gas emission-related parameters is expected between 2016 and 2030, particularly in industrial production, vehicle ownership, and building stock. Besides, Denizli's 2030 emissions are predicted to be 11.9 million tons of CO_2e. In the same year, per capita emissions are expected to be 10.1 tons of CO_2e. A target of 21% has been set for 2030 as a reduction target. Accordingly, it is predicted that Denizli's emissions per capita will be reduced to 8.0 tons of CO_2e in 2030, and total emissions will remain as 9.5 million tons of CO_2e (Denizli Metropolitan Municipality, 2019).

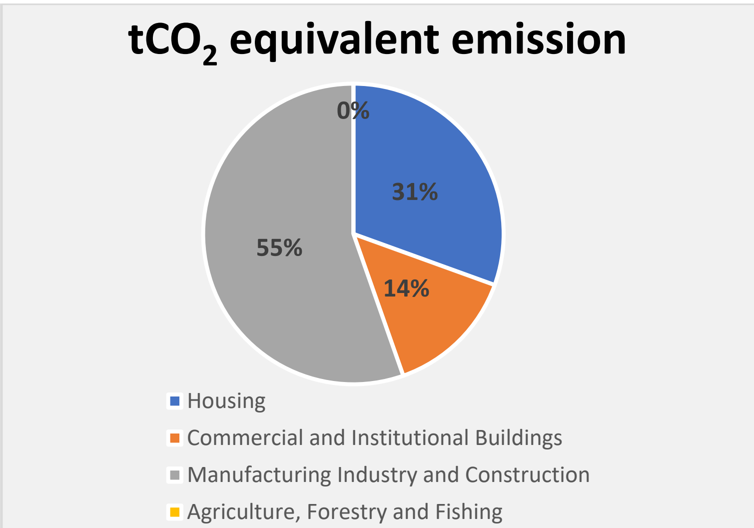

Figure 7. Fixed Sources CO_2 Emission of Denizli

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Gaziantep

The industry has great importance in the economy of Gaziantep province. There is a huge difference between districts in terms of socio-economic levels (SEGE, 2019b). This illustrates that the distribution of resources among districts is not equal. This state may lead to several economic, social, and ecological problems in the time. On the other hand, Şehitkamil is the only district in the first level in the Southeastern Anatolia region.

Population Density and Urbanization Process of Gaziantep Province

The total population of Gaziantep Province in 2015 is 1,931,836 (TURKSTAT, 2021a). Şahinbey and Şehitkamil are Gaziantep's central districts, each of them has a higher population than most of the other cities in Turkey with a population of 845,000 and 710,000 respectively. These two districts constitute 64% of Gaziantep's population. In this respect, Gaziantep has a monocentric development type. 2000 - 2014 in terms of the growth rate of population has taken first place in Gaziantep, Turkey (Figure 8).

The population of the province, which was 214.499 in the 1927 census, increased by 534% in the last 70 years. This growth rate was 317% for the same period in Turkey.

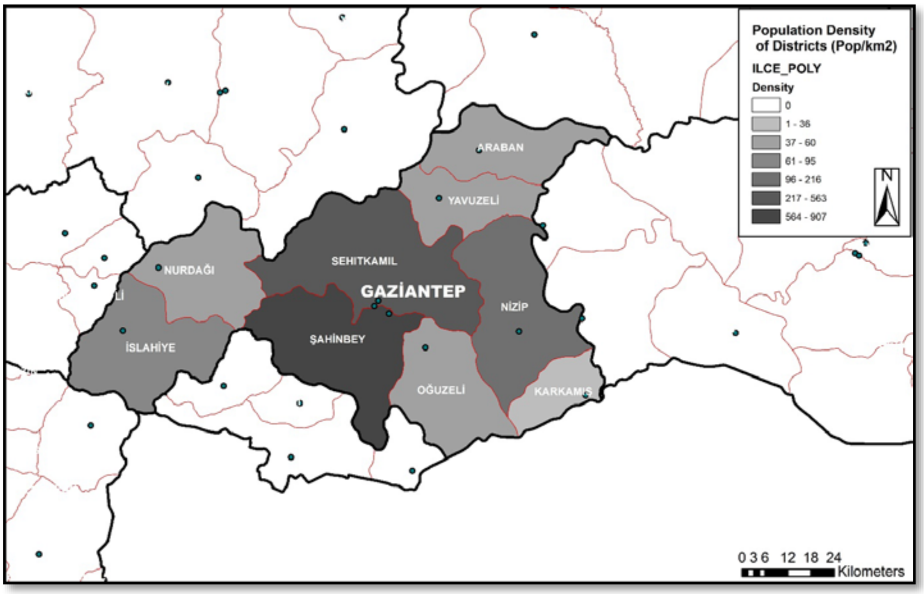

Figure 8. Population Density of Districts of Gaziantep Province in 2015 (This figure created by the authors, using the data of TURKSTATa)

Figure 9 shows the change in the artificial surface of Gaziantep province between 1990 and 2018. According to this map, the existing city form has expanded and a new area has been formed on the north side. The increase in other artificial surfaces occurred almost 4 times during this period.

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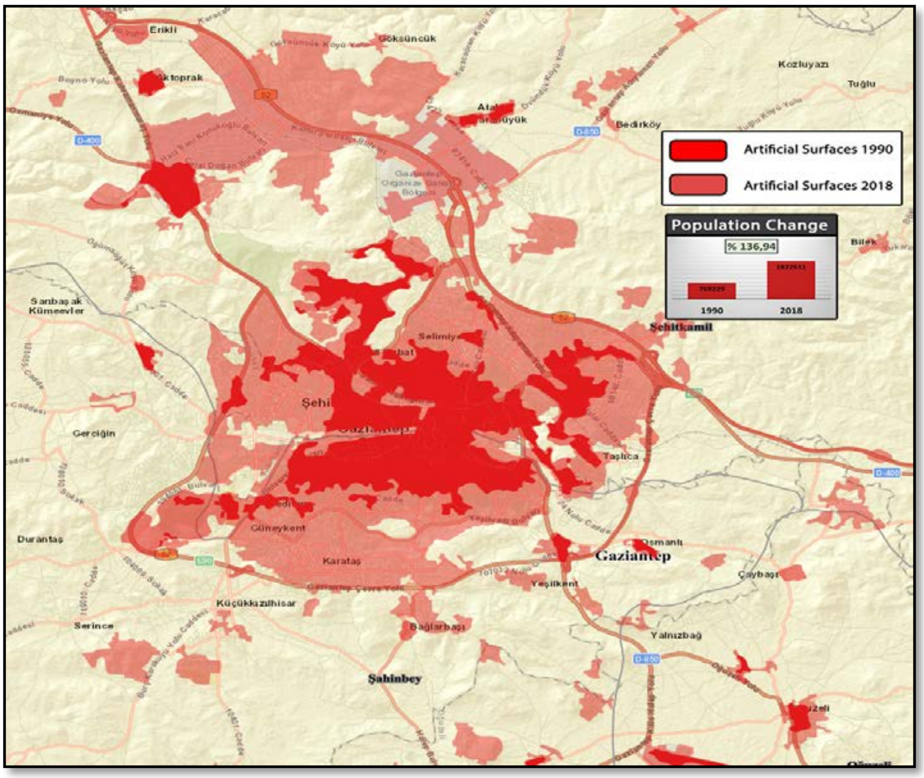

Figure 9. Changes in the artificial surfaces and population in Gaziantep between 1990 and 2018 (This figure created by the authors)

Figure 10 and 11 show in detail the change in the urban fabric and other artificial surface rates of Gaziantep province between 1990 and 2018. The change in the urban fabric between 1990 and 2018 is 56%. Population growth is at the rate of 137%. While population growth is higher than urban fabric, it is considerably less than other artificial surfaces. When this change is compared with the energy consumption rate per capita, energy saving has been achieved in the province based on urban fabric data.

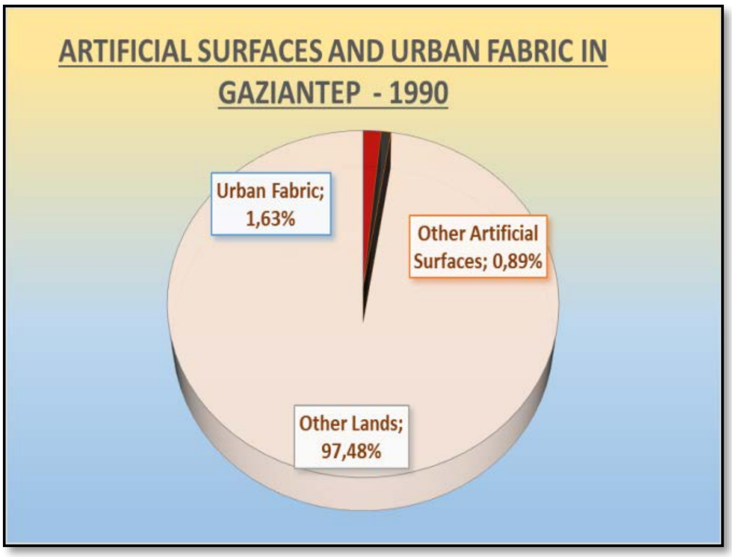

Figure 10. Artificial Surfaces and Urban Fabric in -1990

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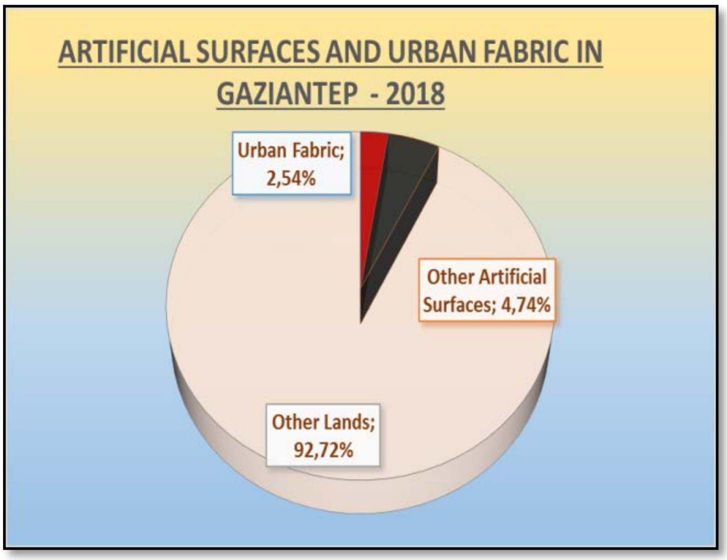

Figure 11. Artificial Surfaces and Urban Fabric– 2018

Carbon Equivalent Emissions of Gaziantep Province

The most important livelihoods in Gaziantep are agriculture, animal husbandry, energy resources, handicrafts, industry, and trade. Phosphate, manganese, and bauxite are mined in Gaziantep, which is extremely poor in terms of mineral resources. Gaziantep, which is the center of the Southeastern Anatolia Project (GAP) with its geographic entrance gate, industry, and commercial volume, keeps under the influence of many provinces around it economically (Provincial Directorate of Environment and Urbanism, 2018).

According to the analysis results obtained with the IPCC approach, the total greenhouse gas emissions of Gaziantep province in 2015 were calculated as approximately 10 million tons of CO_2e. When this amount is compared with the population of Gaziantep in the same year, it means 5.32 tons of CO_2e per capita. This result is below Turkey's average amount of emission 6.04 tons CO_2e per person for 2015 (Gaziantep Metropolitan Municipality, 2016).

The distribution of the CO_2 equivalent emission of Gaziantep province by sectors is given in the Figure 12. The most emissions are made in the industry sector and, transportation takes second place. Forestry is in the last place with 7.97 ktons (Gaziantep Metropolitan Municipality, 2016).

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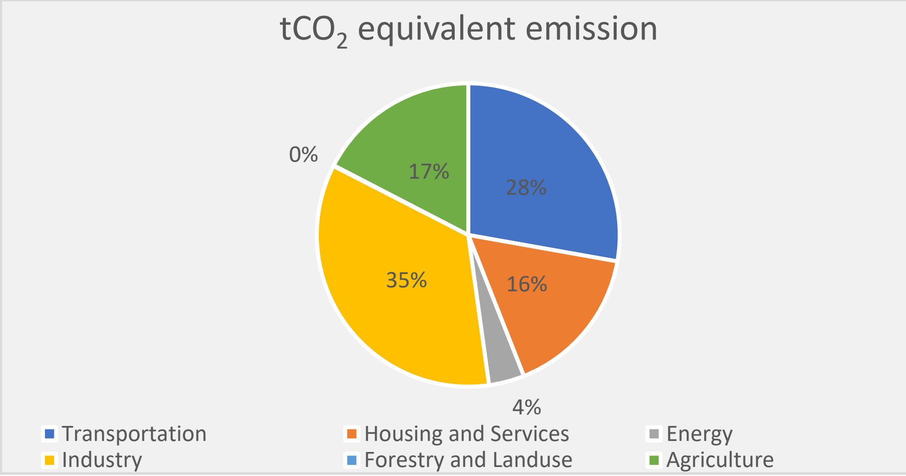

Figure 12. CO_2 equivalent emission of Gaziantep Province by sectors

The fact that the main sector in the province is the industry has also affected GHG emissions. Gaziantep will continue to receive immigration with its business potential. Its population will gradually increase. The fact that the per capita emission rate is lower than the country average. Arrangements should be made in industrial and transportation areas. Besides, city plans and city management issues are very important in terms of fair access to resources in this province, which has very high potential.

Muğla

The main livelihood of the people is tourism, agricultural production, forestry products, underground resources management, traditional handicrafts, and fish production. In Muğla, socio-economic indexes of districts are generally higher than the country average (SEGE, 2019b). This illustrates that the distribution of resources to districts is equal. Moreover, coastal districts indexes are higher than the central district. This example is important in terms of comparing the GHG emissions and socio-economic level.

Population Density and Urbanization Process of Muğla Province

The population density of Muğla province is low when compared to the average of Turkey. With the development of tourism in recent years, a large increase in the population has been observed in the summer months. While the population growth rate in Muğla was 32.45 ‰ in 2008, it decreased to 31.62 ‰ in 2014. The concentration of the population in urban areas means an increase in pressure on the environmental areas (Provincial Directorate of Environment and Urbanism, 2014).

As seen in the Figure 13, many centers have been formed in Muğla province. Especially with the development of coastal tourism, there has been a population shift from the central district of Menteşe to the coastal districts since the 1990s. Even, the population of the districts is higher than the central one. This trend has led to a multicentric development type.

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Figure 13. Population Density of Districts of Muğla Province in 2013 (This figure created by the authors, using the data of TURKSTATa)

Bodrum is an extreme example. However, it is important to see the impact of the frenetic growth of the tourism and construction sectors on ecology. The importance of coastal tourism in Muğla has led to an increase in construction in Bodrum district (Figure 14, 15, and 16). Almost the entire coast of the district has turned into the artificial surface. Because of the high socio-economic level, the number of private car ownership is high, so it is easy to access various functions from anywhere. This is one of the reasons for gaining its current form.

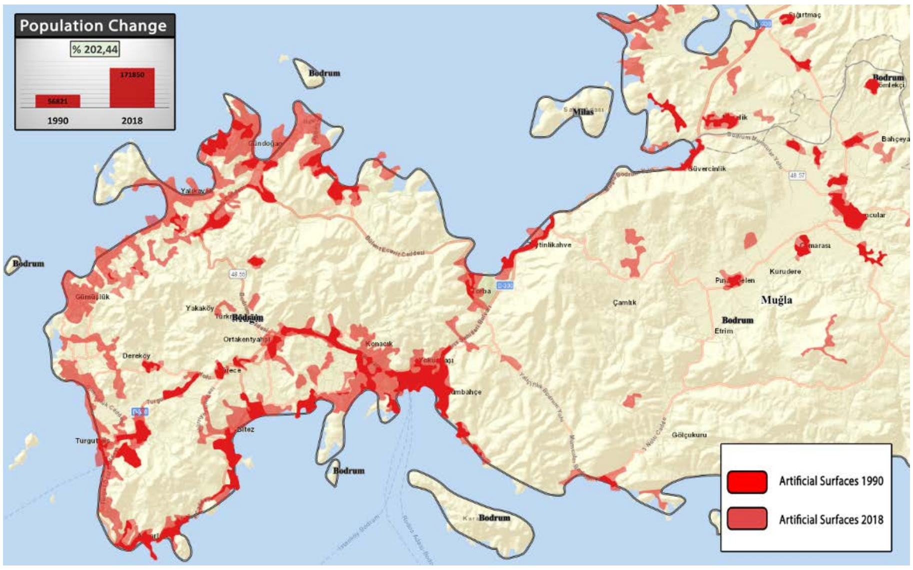

Figure 14. Changes in the artificial surfaces and population in Bodrum between 1990 and 2018 (This figure created by the authors for this paper)

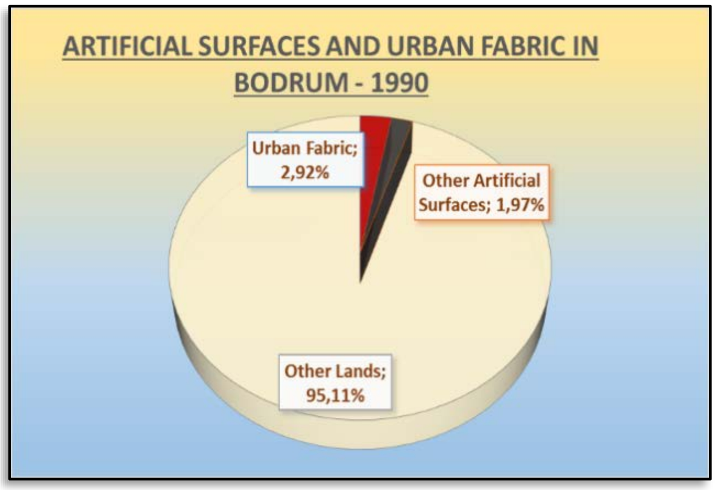

Figure 15. Artificial Surfaces and Urban Fabric in -1990

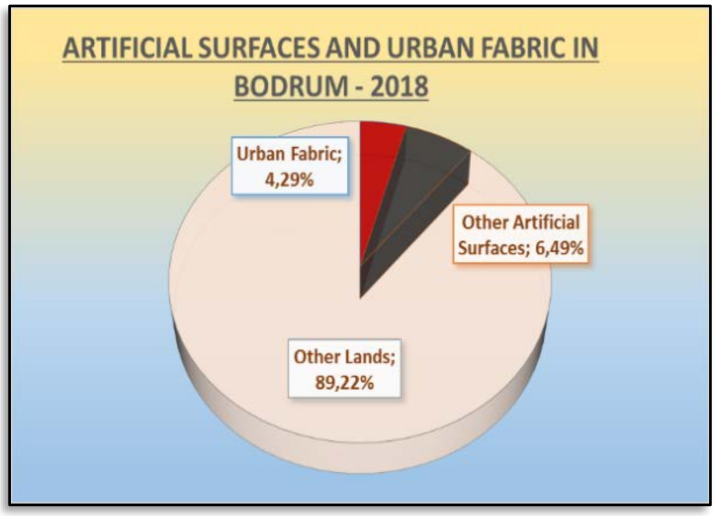

Figure 16. Artificial Surfaces and Urban Fabric in -2018

One of the districts where population growth is very high is Marmaris (Figure 17). However, its structural form has not changed much like Bodrum's. Rather, it resulted in the expansion of its current form.

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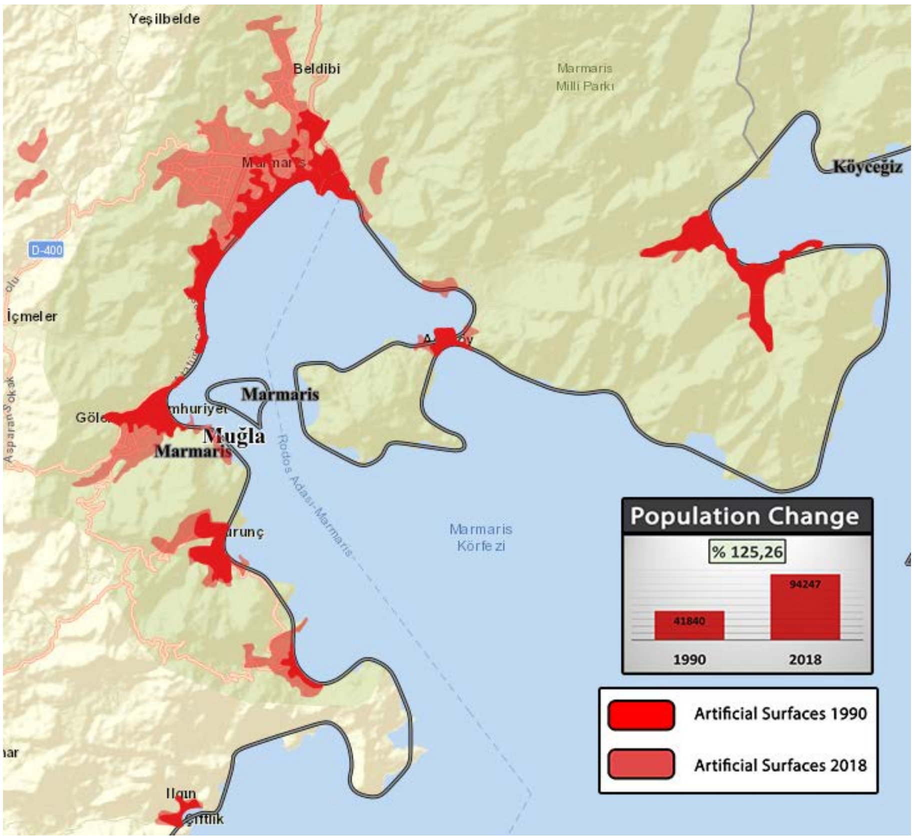

Figure 17. Changes in the artificial surfaces and population in Marmaris between 1990 and 2018 (This figure created by the authors)

It is observed that fragmented settlements has been formed in Menteşe. (Figure 18). According to the population growth rate, the increase in construction is quite high.

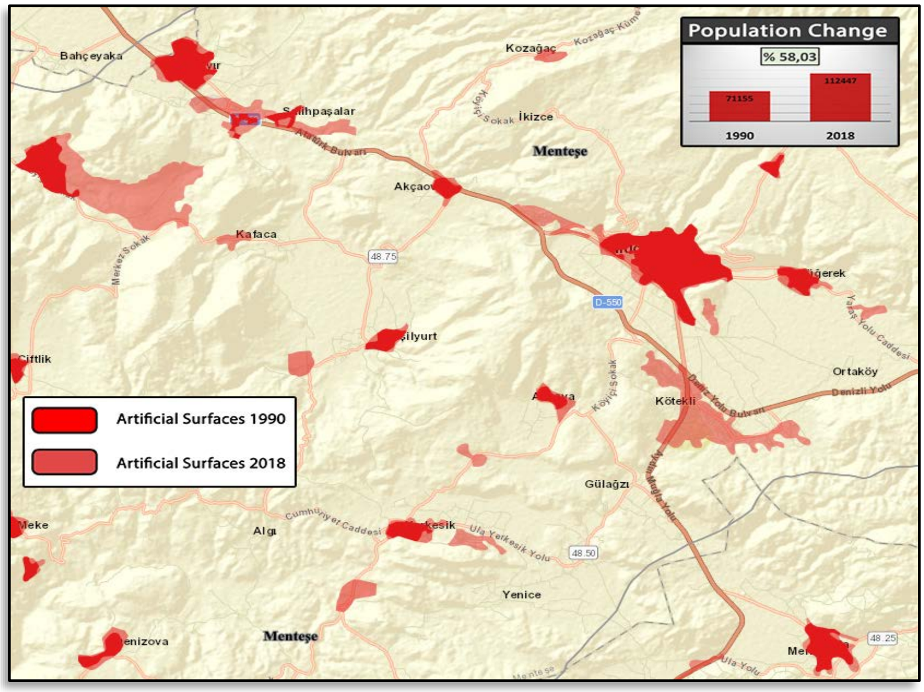

Figure 18. Changes in the artificial surfaces and population in Menteşe between 1990 and 2018 (This figure created by the authors for this paper)

In Milas and Fethiye, between 1990 and 2018, artificial surface increased more than the population increase. This result can be explained by the seasonal population increase and buildings for this demand.
In Figure 19 and 20, Bodrum, Fethiye, Marmaris, Menteşe, and Milas districts with a population of over 80,000 have been studied. General structuring of the city form, which is mostly fragmented, is far from a compact development type. Between 1990 and 2018, the total artificial surface increase in these five districts is 79%. Due to the seasonal increase of the population, the connection between population - artificial surface - energy consumption could not be clarified.

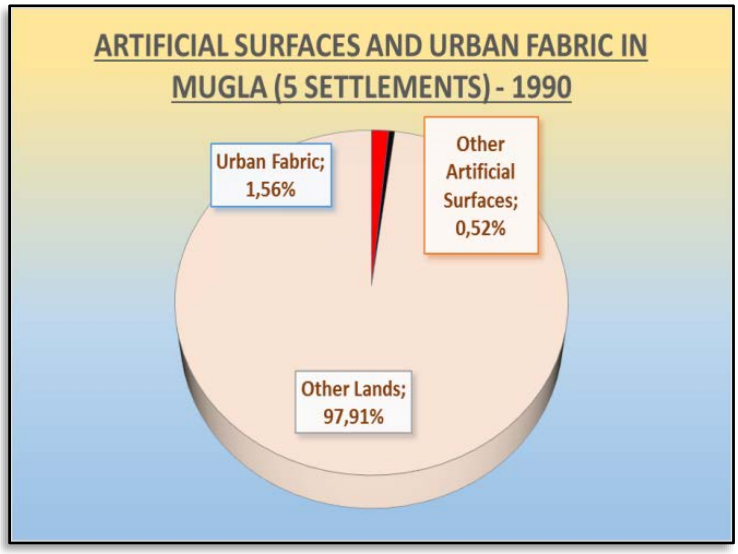

Figure 19. Artificial Surfaces and Urban Fabric in -1990 between 1990 and 2018 (This figure created by the authors for this paper)

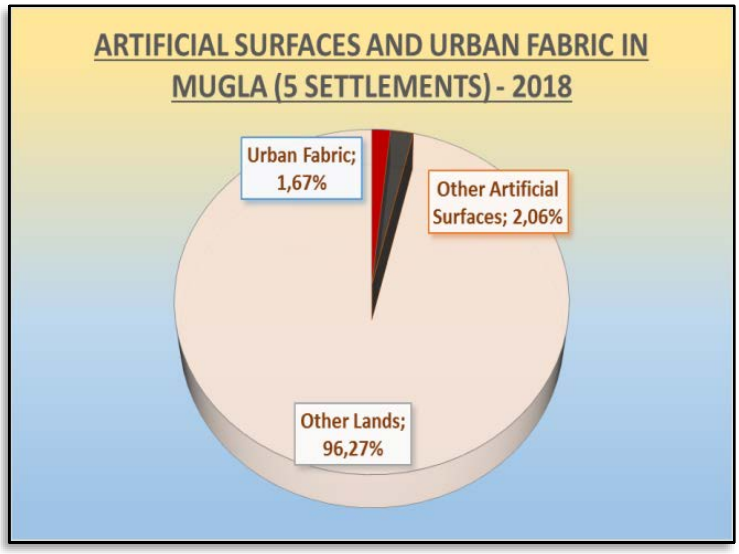

Figure 20. Artificial Surfaces and Urban Fabric in -2018between 1990 and 2018 (This figure created by the authors)

Carbon Equivalent Emissions of Muğla Province

Total emissions of Muğla calculated according to the GPC BASIC approach for 2013 were calculated as 11.203.766 tCO_2 equivalent when thermal power plants and airway transportation were added. While 986.093 tCO_2 equivalent of these emissions is Scope 1- Direct Emissions, 1.217.672

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tCO_2e are due to the total electricity consumption in Muğla. When these two major emission sources are excluded, total emissions are equivalent to 3,247,861 tCO_2, while 2,030,189 tCO_2e arises from the total electricity consumption of Scope 1 and 1,217,672 tCO_2e (Muğla Metropolitan Municipality, 2013).

When it is calculated in thermal power plants in the evaluations, it constitutes the most important emission source of the city, followed by airline-based emissions (Figure 21). However, when these two emission sources are excluded, solid waste is the largest greenhouse gas emission source in the city with 893,632 tCO_2e (Figure 22). With a share of 653,817 tCO_2, emissions from diesel vehicles come in second place. This is followed by electricity consumption of 628,983 in commercial/corporate buildings, 380,192 tCO_2 domestic electricity consumption, and commercial electricity consumption. Finally, domestic coal consumption comes with a share of 71,414 tCO_2e (Muğla Metropolitan Municipality, 2013).

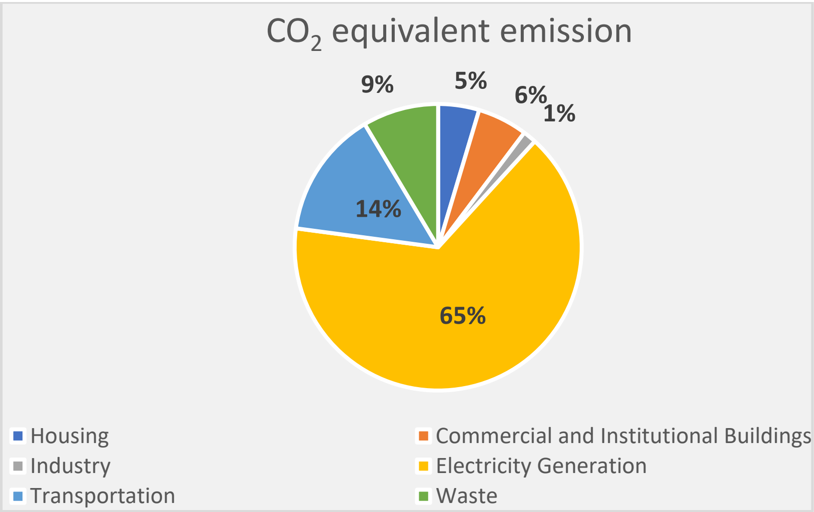

Figure 21 CO_2 equivalent emission of sectors in Muğla

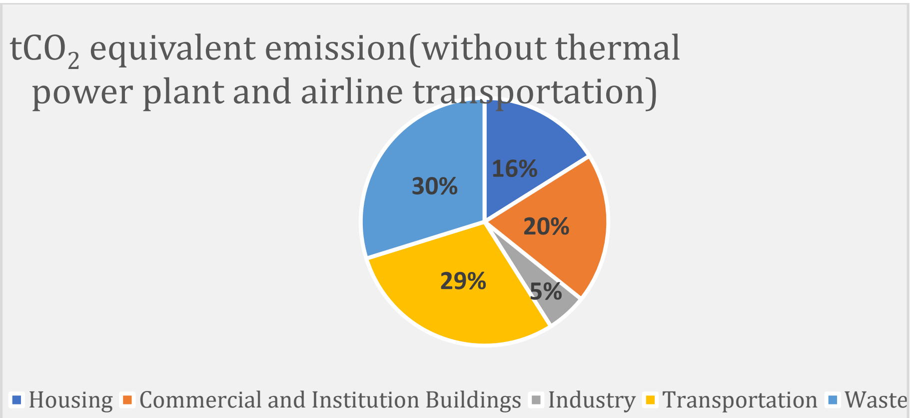

Figure 22 CO_2 equivalent emission(without thermal power plant and airline transportation) of sectors in Muğla

In the studies carried out for the coastal Aegean region where Muğla is located, the temperature increase is predicted to be more limited in the first years, it is expected that the temperature increase will be higher in the future (after 2040). On the other hand, the winter precipitation will increase. Since the tourism sector has an important place in the economy of the province, it is estimated that the expected changes lead to disasters such as floods and weather events, as well as problems such as loss of income, increase in expenses (cooling and energy consumption).

Findings

The findings of cities' CO_2 emission rates have been classified according to road transport, housing, and building services, waste. Also, data on the number of private cars and the average number of households were used.

Road Transport

In this section, the greenhouse gas emission rates of the provinces originating from road transport are compared. While comparisons are being made; population, income level, and a total number of private vehicles data were used.

As seen in the Table 3 and Figure 23, Muğla is the province with the highest transport emission per capita. This is followed by Denizli and Gaziantep provinces, respectively. In Table 4, where the number of private vehicles is compared to the population, Muğla is shown to be the highest province followed by Denizli and Gaziantep, respectively. In Table 5, the per capita Gross Domestic Product (GDP) values are compared, Muğla is the highest, and Gaziantep is the lowest one.

These results show that transport emission rates are directly related to income level.

Table 3. Road transport emission rate per capita of provinces (This table created by the authors, using the data of TURKSTAT, 2021a)

Province	Population	GHG (tCO_2e)	GHG/pop
Denizli	1005687	534044	0,531
Gaziantep	1931836	950000	0,49
Muğla	866665	934689	1,07

Table 4. The ratio of private car ownership to the population by provinces (This table created by the authors, using the data of TURKSTAT, 2021b)

Province	Population	Number of Private Cars		Num.prvt.car/pop
Denizli	1005687	203194		0,42
Gaziantep	1931836	237561		0,27
Muğla	866665	214209		0,60

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Table 5. GDP of Provinces (This table created by the authors, using the data of TURKSTAT, 2021c)

Province	Gdp per capita (TL)	Gdp per capita($)	Report Year
Denizli	30199	9988	2016
Gaziantep	21731	8009	2015
Muğla	24360	12793	2013

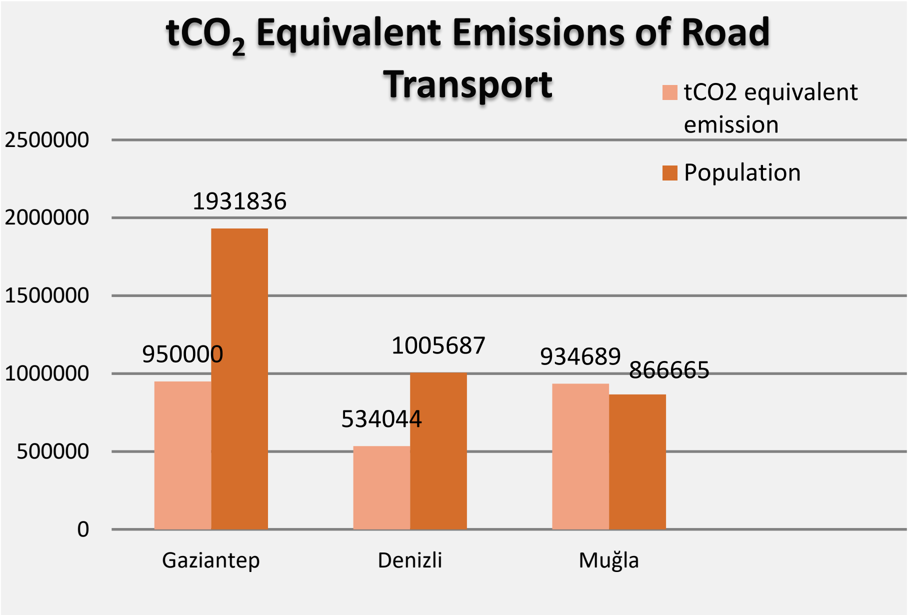

Figure 23. CO_2 Equivalent Emissions of Road Transport of the Provinces (This figure created by the authors for this paper)

Waste

Muğla's high waste emission rate is caused by thermal power plants. As seen in the Table 6 and Figure 24, it is obvious that thermal power plants devastate nature. On the other hand, Denizli produces more waste than Gaziantep. This is in line with their population size.

Table 6. Waste emission rates of provinces (This table created by the authors)

Province	Population	Waste emission (tCO_2e)	W. GHG / Pop.
Denizli	1005687	78092	0,077
Gaziantep	1931836	125000	0,06
Muğla	866665	970664	1,12

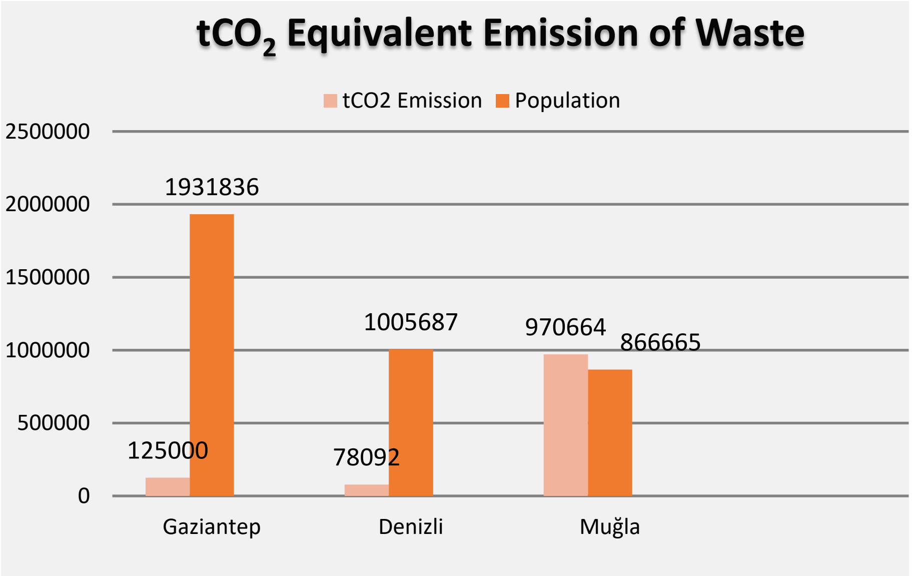

Figure 24. CO_2 Equivalent Emissions of Waste of the Provinces (This figure created by the authors for

Housing and Services

In Tables 7 and 8 and Figure 25, comparing the average household size with the GHG emission rates of houses and services, it is reasonable that Gaziantep has the lowest rate. However, the reason for Denizli's high emission rate is affected by other factors.

Table 7. Average Household Size of Provinces (This table created by the authors using the data of TURKSTAT, 2021d for this paper)

Province	Average household size	Report Year
Denizli	3,07	2016
Gaziantep	4,32	2015
Muğla	2,97	2013

Table 8. GHG Emission Rates of Housing and Services of Provinces (This table created by the authors for this paper)

Province	Population	Emission of Housing and Services (tCO_2e)	GHG/Pop
Denizli	1005687	1448312	1,44
Gaziantep	1931834	2013350	1,04
Muğla	866665	1143702	1,32

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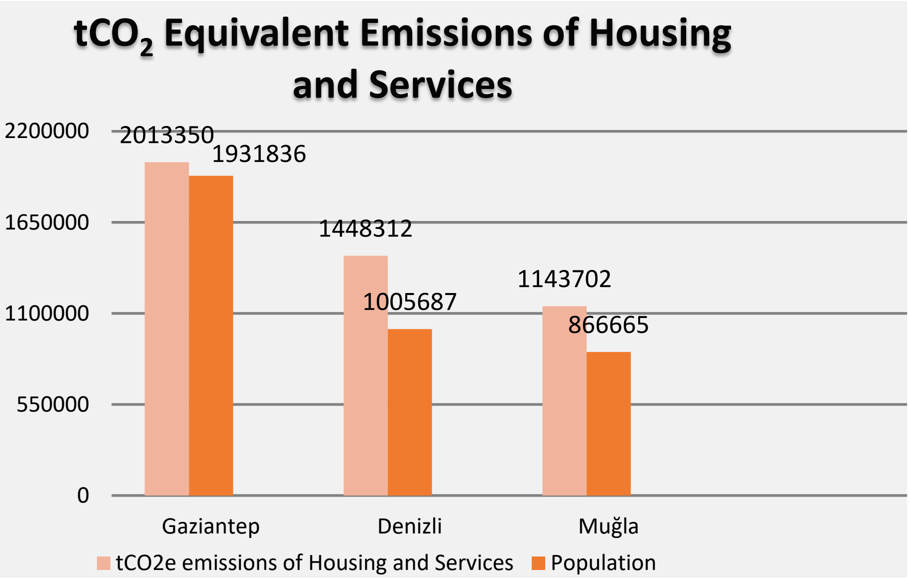

Figure 25. CO_2 Equivalent Emissions of Housing and Services of the Provinces (This figure created by the authors for this paper)

RESULTS AND DISCUSSION

The population has shifted from the central district towards the coast due to tourism. With the increase of population density in the coastal districts, Muğla province has gained a multi-centered form. Moreover, there is a direct relationship between the high-income level and the number of private cars. Due to the high socio-economic level, the use of private cars has increased. Regarding this, proximity to services has lost its importance. Moreover, forms diverging from the center and coastal settlements have occurred. The high emissions in road transport can be explained by these reasons.

Table 9 summarizes the results of the study by sectors. The effect of thermal power plants on nature in Muğla shows the importance of the basic sectors on urban resilience.

Average household size affects greenhouse gas emissions of housing and services. In addition to this, it is thought that there are other factors affecting GHG emissions in housing and services.

There is a positive relationship between population and waste emission rates. However, other reasons also affect these rates.

Table 9. Results (This table created by the authors for this paper)

Sectors	**Denizli**	**Gaziantep**	**Muğla**
Road Transport	Medium Value	Low income level / low n. of private car / low GHG emission	High income level /high n. of private car/ high GHG emission
Waste	More research needed	More research needed	Devastating sectoral impact
Housing and Service Buildings	More research needed	High population density / low GHG emission	More research needed

CONCLUSION

In this study, urban resilience is discussed within the framework of city size, hierarchy, and development type. The greenhouse gas emission rates are evaluated by the criteria of population, density, distribution of building density, artificial surface, socio-economic level, basic economic sectors, and housing type.

A hierarchical urban system structure is essential for the resilience of the city to be able to organize itself, adapt to external changes faster, and create a complex and strong structure. Each of the case cities in this study does not fully meet the hierarchy criteria. Because of the rentier ambitions the city size of the districts are close to each other in Muğla, especially in the Bodrum district. Thus, the hierarchical structure has gradually weakened. Medium-scale districts are insufficient in Denizli and Gaziantep provinces where currently some cities are overgrown. As a result, small-scale cities are directly connected to large-scale cities, which creates a problem in terms of coordination between small and large-scale cities. For this reason, the hierarchical structure has not developed enough in all three cities.

City size is an important criterion for low infrastructure cost, efficient use of resources, and capacity to access capital of all kinds. Yet, this criterion may differ in the resilience of the city according to the factors such as population, area size, and distribution of various urban functions. There is a relationship between population and GHG emissions. However, this relationship is affected by density, development type, change of artificial surfaces, and socio-economic level. Besides, the high-income level is effective in increasing GHG emissions. The case studies show that if the expansion of artificial surfaces is more than population growth, there is an increase in energy consumption and hence increase in GHG emissions.

Development type includes criteria such as compactness, urban sprawl, mono-centric and poly-centric urban forms, mixed land use, and diversity of building type. Currently, the form of Muğla province shows a poly-centric structure, while Gaziantep and Denizli provinces have a mono-centric structure. Actually, the development type of Muğla province has changed in time as the coastal zone has been attracting more people with a rising demand for new constructions. While coastal districts of Muğla have started to develop due to tourism, the city center (Menteşe district) has relatively shrunk. Since the development type continues in a fragmented way, city forms are gradually growing away from compactness, which causes the city structure to turn into a car-oriented. Therefore, the GHG emission level of the road transport has risen.

The economic sectors have great impact on the urban resilience. Thermal power plants in Muğla have a destructive effect on the urban ecology. In this respect, it is crucial to base the city economies on more sustainable sectors.

Gaziantep province is the case with the lowest emission rate per capita with its high population and relatively low socio-economic level criteria. Although the province of Denizli has the same development type as

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Gaziantep, its population and socio-economic development ranking are very different. This situation shows that the measures of city size and socio-economic income level affect the amount of greenhouse gas emission significantly. In this respect, these two examples are also particular cases.

In summary, measures of population density, development type, hierarchy, income level, and the economic sector must be taken into account to ensure urban resilience. Yet, as these variables will differ in each province, their effects will also vary. There is no optimum form for urban resilience. Thus, the issue of urban resilience should be handled in a multifaceted and multidimensional way. For Turkish cities, there is a need for a comprehensive urban policy agenda towards resilience.

CONFLICT INTEREST

No conflict of interest was declared by the authours.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

ETHICS COMMITEE APPROVAL

Ethics committee approval was not required for this article.

LEGAL PUBLIC/PRIVATE PERMISSIONS

No survey and in-depth interviews, that require legal permissions, were conducted during this research.

REFERENCES

Ajibade, I. (2017). Can a future city enhance urban resilience and sustainability? A political ecology analysis of Eko Atlantic city, Nigeria. *International Journal of Disaster Risk Reduction*, *26*, 85-92.

Allan, P., Bryant, M., Wirsching, C., Garcia, D., & Teresa Rodriguez, M. (2013). The influence of urban morphology on the resilience of cities following an earthquake. *Journal of Urban Design*, *18*(2), 242-262.

Altun, A. Ö., & Tezer, A. (2019). A Preliminary Study on Defining Urban Resilience for Urban Planning: The Case of Sultanbeyli, Istanbul. *Cilt: 15*, 77.

Bahadur, A., & Tanner, T. (2014). Transformational resilience thinking: putting people, power and politics at the heart of urban climate resilience. *Environment and Urbanization*, *26*(1), 200-214.

Béné, C., Mehta, L., McGranahan, G., Cannon, T., Gupte, J., & Tanner, T. (2018). Resilience as a policy narrative: Potentials and limits in the context of urban planning. *Climate and Development*, *10*(2), 116-133.

Brand, F. S., & Jax, K. (2007). Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society*, *12*(1).

Davidson, D. J. (2010). The applicability of the concept of resilience to social systems: some sources of optimism and nagging doubts. *Society and natural resources*, *23*(12), 1135-1149.

Denizli Metropolitan Municipality. (2019). Denizli İklim Değişikliği Eylem Planı (2016 – 2030).

Fang, C., Wang, S., & Li, G. (2015). Changing urban forms and carbon dioxide emissions in China: A case study of 30 provincial capital cities. *Applied energy*, *158*, 519-531.

Faulkner, J. P., Murphy, E., & Scott, M. (2020). Developing a holistic 'vulnerability-resilience'model for local and regional development. *European Planning Studies*, *28*(12), 2330-2347.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, *16*(3), 253-267.

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and society*, *15*(4).

Gaziantep Metropolitan Municipality. (2016). Gaziantep İklim Değişikliği Eylem Planı

Habitat, U.N. (2016). World cities report 2016: Urbanization and development: Emerging futures. *Nairobi: United Nations*.

Hachem, C. (2016). Impact of neighborhood design on energy performance and GHG emissions. *Applied energy*, *177*, 422-434.

Hoffman, L. M. (2014). From sustainability to resilience: Why locality matters. In *From Sustainable to Resilient Cities: Global Concerns and Urban Efforts*. Emerald Group Publishing Limited.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), 1-23.

Irajifar, L., Sipe, N., & Alizadeh, T. (2016). The impact of urban form on disaster resiliency. *International Journal of Disaster Resilience in the Built Environment*.

Larson, W., & Yezer, A. (2015). The energy implications of city size and density. *Journal of Urban Economics*, *90*, 35-49.

Lee, S., & Lee, B. (2014). The influence of urban form on GHG emissions in the US household sector. *Energy Policy*, *68*, 534-549.

Louf, R., & Barthelemy, M. (2014). How congestion shapes cities: from mobility patterns to scaling. *Scientific reports*, *4*(1), 1-9.

Marks, D., & Lebel, L. (2016). Disaster governance and the scalar politics of incomplete decentralization: Fragmented and contested responses to the 2011 floods in Central Thailand. *Habitat International*, *52*, 57-66.

Mayer, A., Haas, W., & Wiedenhofer, D. (2017). How countries' resource use history matters for human well-being–an investigation of global patterns in cumulative material flows from 1950 to 2010. Ecological Economics, 134, 1-10.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and urban planning*, *147*, 38-49.

DOI: 10.15320/ICONARP.2021.180

Muğla Metropolitan Municipality. (2013). Muğla İklim Değişikliği ve Sürdürülebilir Enerji Eylem Planı.

Pickett, S. T., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and urban planning*, *69*(4), 369-384

Provincial Directorate of Environment and Urbanism, (2014). Muğlaİli 2014 Yılı Çevre Durum Raporu, Denizli Valiliği Çevre ve Şehircilik İl Müdürlüğü. URL: https://webdosya.csb.gov.tr/db/ced/editordosya/Mugla_icdr2014.pdf

Provincial Directorate of Environment and Urbanism, (2016). Denizli İli 2016 Yılı Çevre Durum Raporu, Denizli Valiliği Çevre ve Şehircilik İl Müdürlüğü. URL:http://webdosya.csb.gov.tr/db/ced/editordosya/Denizli_icdr2016.pdf

Provincial Directorate of Environment and Urbanism, (2018). Gaziantep İli 2018 Yılı Çevre Durum Raporu, Denizli Valiliği Çevre ve Şehircilik İl Müdürlüğü. URL: https://webdosya.csb.gov.tr/db/ced/icerikler/gaz-antep_-cdr2018-20200210112211.pdf

Revi, A., Satterthwaite, D., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R. B., Pelling, M., ... & Sverdlik, A. (2014). Towards transformative adaptation in cities: the IPCC's Fifth Assessment. *Environment and Urbanization*, *26*(1), 11-28.

Rosenzweig, C., Solecki, W., Romero-Lankao, P., Mehrotra, S., Dhakal, S., Bowman, T., & Ibrahim, S. A. (2015). ARC3. 2 Summary for City Leaders Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network.

Salat, S., & Bourdic, L. (2012). Systemic resilience of complex urban systems. *TeMA-Journal of Land Use, Mobility and Environment*, *5*(2), 55-68.

Salat, S. (2017). A systemic approach of urban resilience: power laws and urban growth patterns. *International Journal of Urban Sustainable Development*, *9*(2), 107-135.

Scott, M. (2021). Resilience, Risk, and Policymaking. In *COVID-19 and Similar Futures* (pp. 113-118). Springer, Cham.

SEGE-2011, (2013). İllerin ve Bölgelerin Sosyo-Ekonomik Gelişmişlik Sıralaması Araştırması, T.C. Kalkınma Bakanlığı Bölgesel Gelişme ve Yapısal Uyum Genel Müdürlüğü, Ankara.

SEGE-2017, (2019a), İllerin ve Bölgelerin Sosyo-Ekonomik Gelişmişlik Siralamasi Araştirmasi, Kalkınma Ajansları Genel Müdürlüğü Yayını Sayı: 3, Aralık, Ankara.

SEGE-2017, (2019b), İlçelerin Sosyo Ekonomik Gelişmişlik Siralamasi Araştirmasi, Kalkınma Ajansları Genel Müdürlüğü Yayını Sayı: 3, Aralık, Ankara.

Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., ... & Ramaswami, A. (2014). Human settlements, infrastructure and spatial planning.

ICONARP – Volume 9, Issue 2 / Published: 21.12.2021

Sharifi, A. (2019). Resilient urban forms: A macro-scale analysis. *Cities*, *85*, 1-14.

Sharifi, A., Yamagata, Y., (2018). Resilient Urban Form: A Conceptual Frame-work, in: Resilience-Oriented Urban Planning: Theoretical and Empirical Insights (Y. Yamagata, A. Sharifi, eds.), Springer.

The Rockefeller Foundation and ARUP. (2014). City resilience framework.

TURKSTAT, (2021a), İl ve cinsiyete göre il/ilçe merkezi, belde/köy nüfusu ve nüfus yoğunluğu, 2007-2020.

TURKSTAT, (2021b), Yıllara göre motorlu kara taşıt sayısı, il düzeyi (meta veri).

TURKSTAT, (2021c), İl bazında gayrisafi yurt içi hasıla, iktisadi faaliyet kollarına (A10) göre, cari fiyatlarla, 2004-2019.

TURKSTAT, (2021d), İllere göre ortalama hane halkı büyüklüğü 2008-2020.

UN, (2015). Transforming our world: the 2030 Agenda for Sustainable Development. *United Nations: New York, NY, USA*.

UNFCCC, (2020). National greenhouse gas inventory data for the period 1990–2018. Retrieved from https://unfccc.int/ on 28.01.2021

Yalçıner Ercoskun, O. (2012). A paradigm shift towards urban resilience. In *Green and ecological technologies for urban planning: Creating smart cities* (pp. 1-16). IGI Global.

Resume

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