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The Effects of Climate Change on Coastal Areas and Coastal Property and Floating Cities As a Solution Proposal

İklim Değişikliğinin Kıyı Alanları ile Kıyı Mülkiyetine Etkileri ve Bir Çözüm Önerisi Olarak Yüzen Şehirler

Çağla DALKIRAN[1], Ece İlayda YÖRÜK[2], Mehmet ÜLGER[3]

Öz

Bu araştırma, iklim değişikliğinin kıyı bölgelerindeki su seviyelerine olan etkilerini incelemekte ve bu etkilerle başa çıkma stratejilerine odaklanmaktadır. Yapılan araştırmalar, iklim değişikliğinin deniz seviyelerindeki yükselme ile su taşkınları, yerleşim alanlarının kaybı ve zorunlu göç gibi olumsuz etkiler yaratacağını göstermektedir. Bu durum, kıyı bölgelerinde iklim değişikliğiyle uyumlu politikaların geliştirilmesini zorunlu kılmaktadır. Makale, bu bağlamda sürdürülebilir ve dirençli kent planlaması stratejilerini ele almaktadır. Ayrıca, gelecekteki su seviyesi yükselmelerine karşı etkili bir çözüm olarak öne çıkan yüzen şehir projelerini değerlendirmektedir. Yüzen şehirler, su seviyelerindeki artışa uyum sağlayabilen, doğa dostu, kendi enerjisini üretebilen ve sürdürülebilir yaşam alanları sunabilen inovatif konseptler sunmaktadır. Araştırma, bu projelerin kıyı bölgelerindeki mülkiyet sorunlarına ve çevresel sürdürülebilirliğe yönelik potansiyel avantajlarını incelerken, aynı zamanda bu projelerin gelecekteki kıyı alanları için önemli bir alternatif olabileceğini vurgulamaktadır. Sonuç olarak, iklim değişikliğiyle mücadelede etkili ve sürdürülebilir stratejilerin geliştirilmesinde yüzen şehir projelerinin rolünü vurgulayarak, bu alandaki geleceğe yönelik araştırmalara ve Türkiye'de uygulanabilirliğine ışık tutmaktadır.

Anahtar Kelimeler: İklim Değişikliği, Kıyı Alanları, Yüzen Şehirler, Mülkiyet, Kıyı Alanları Yönetimi

ABSTRACT

This research examines the impacts of climate change on water levels in coastal areas and focuses on strategies to cope with these impacts. Research shows that climate change will have negative impacts such as rising sea levels, flooding, loss of settlements and forced migration. This necessitates the development of climate change compatible policies in coastal areas. The paper addresses sustainable and resilient urban planning strategies in this context. It also evaluates floating city projects that stand out as an effective solution against future water level rises. Floating cities offer innovative concepts that can adapt to rising water levels, are eco-friendly, self-powered and offer sustainable living spaces. The research examines the potential advantages of these projects for addressing property issues and environmental sustainability in coastal areas, while emphasizing that these projects could be an important alternative for future coastal areas. As a result, it emphasizes the role of floating city projects in the development of effective and sustainable strategies to combat climate change and sheds light on future research in this field and its applicability in Turkey.

Keywords: Climate Change, Coastal Areas, Floating City, Ownership, Coastal Areas Management

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1. INTRODUCTION

In the globalizing world, unconscious use of natural resources and rapid industrialization steps without considering environmental impacts can be shown to be among the important reasons for the climate crisis. The destructive effect of climate change is that undesirable natural events such as forest fires, drought, rising ocean and sea levels and floods, which occur with the increase in temperatures, not only adversely affect the ecosystem but also put settlements under serious risk. Sea levels are rising every day, especially as a result of the melting of Antarctic and Greenland glaciers (NOAA, 2020). This situation causes floods and destruction in coastal areas.

Regarding coastal areas, which are one of the areas where the effects of climate change are felt the most; while the population living within 100 km from the coast was 2.3 billion in 2000, this number is expected to be 3.1 billion in 2025 (Kay and Alder, 2005). According to United Nations data, 680 million people live in low-lying coastal areas that are located beyond the coastline and formed by coastal movements, and this number is expected to reach 1 billion people by 2050 (UN, 2022). All these data show how important coastal areas are in the world. In addition, coastal cities are important locations where economic activities and tourism areas are concentrated.

Since floods and erosion caused by the climate crisis damage coastal areas, governments are working to prevent these threats. Among the issues discussed by the United Nations Intergovernmental Panel on Climate Change (IPCC) is the situation of settlements in coastal areas. Factors such as the diversity of economic activities in these areas and their advantages in terms of tourism also affect the density of the population. According to the scientific report prepared by the IPCC, factors such as floods, drought, heat waves, ocean acidification caused by climate change are estimated to cause serious damage to settlements and ecosystems in coastal areas. In particular, predicting the extent of the increase in water level in the coming years will be effective in taking the necessary measures for the destruction of coastal areas. According to the IPCC, sea level rise will continue and the water height will rise between 40 cm and 1 m by 2100 (IPCC, 2022). The National Aeronautics and Space Administration (NASA) and the National Center for Space Exploration (CNES) have been monitoring sea level height since 1993 with the help of the TOPEX/Poseidon satellite. According to these data analyses, the water level in the global seas increased by 27 cm from 2021 to 2022. Based on 30 years of satellite measurements, according to NASA's sea level change science team, the projected rate of sea level rise will be 66 cm per year by 2050 (Lee, 2023).

Turkey is among the countries at risk for the devastating effects of global warming. Especially in coastal cities with high population density, the rise in sea level is a cause for concern. In addition to the economic activities carried out in coastal areas, residential areas are also expected to be adversely affected. It is estimated that cities such as Istanbul and İzmir will be among the cities most affected by sea level rise in 2100 (Oğan and Emekli, 2022). It is of utmost importance that risk analyses are made correctly for these cities, which are among the top economic centers in Turkey, and that planning and precautions are taken in consideration of these risks.

Against all these negative scenarios, policy makers are addressing climate change adaptation approaches within the scope of combating climate change. The aim of global climate change adaptation policies is to make cities resilient against the impacts of climate change. For this reason, both national and international meetings discuss the situation of cities for the coming years and propose solutions. These solutions consist of alternative urban living spaces as well as making cities resilient against disasters.

Many designers around the world have designed projects to create settlements resistant to rising sea levels but have not been able to realize them. The common point of these projects is the theory of life

on water. These projects, called floating cities, are conceptual works that can generate their own energy and try not to harm nature and the ecosystem. The United Nations held the First UN High-Level Roundtable on Sustainable Floating Cities on April 3, 2019 in New York to propose solutions for coastal cities threatened by rising sea levels and floods.

Oceanix City, a sustainable floating city project designed by Ocenaix, MIT Ocean Engineering Center and BIG-Bjarke Ingels Group, an architecture firm, was introduced at the meeting. Another important point of the meeting was that engineers, politicians and scientists came together to discuss solutions to prevent rising sea levels and flooding (UN, 2019).

This study discusses the impact of climate change on coastal areas and coastal property. After presenting information on the conceptual framework, the effects of climate change on coastal areas are emphasized. Floating cities are mentioned as a solution proposal. A literature review was conducted on the prediction that climate change has negative impacts especially on coastal areas. Based on this research, the impact of climate change on coastal areas and coastal property was focused on by using the evaluation research method, one of the qualitative research methods. It is aimed to examine the impact of rising water levels on coastal areas and to examine the concept of floating cities as an alternative to endangered settlements. A considerable proportion of the population lives in coastal cities. It is estimated that sea level rise will continue in the coming years due to climate change and coastal cities will become risky areas. Therefore, it is extremely important to reduce the risk in coastal cities and make them resilient. This study is thought to fill an important gap in terms of ensuring the creation of coastal cities compatible with climate change.

2. EVALUATION OF PREVIOUS RESEARCH AND SUMMARY OF LITERATURE

Mutlu and Selçuk (2023) emphasized in their study that global warming and changing climatic conditions cause sea level rise and forced migration, and therefore new settlement areas need to be built. Oceanix City, Maldives Floating City and Aequorea projects were examined as solutions to climate change and their advantages and disadvantages were discussed.

The study of An et al. (2021) focuses on the climate refugee problem. Environmental degradation caused by climate change also leads to a humanitarian crisis. It is mentioned that climate change-based migration is global, and countries that are economically strong and act in accordance with climate change adaptation policies will be less affected by this process.

In the research conducted by Lavarone and Kaya (2021), it is stated that sea level rise poses a risk for coastal cities and the action plans of 16 metropolitan municipalities in Turkey against these risks are examined. According to the data obtained from the study on the basis of discourse analysis and findings, it was concluded that local governments are indifferent to adaptation to climate change and the risk of sea level rise, and that the action plans of local governments are far from local and sustainable measures against the risk of sea level rise.

In the study conducted by Tuğaç (2022a), the impact of the climate change crisis on cities was emphasized and it was stated that there is a bidirectional cause-and-effect relationship between cities and climate change. According to the study, it was determined that greenhouse gas mitigation and adaptation actions to the effects of climate change in the fight against climate change also contribute significantly to ensuring the resilience of cities. At the same time, urban opportunities can be directed towards providing solutions in combating climate change.

In the study examining the report published by IPCC in 2022, the headings of the report are summarized as Observed and Projected Impacts and Risks, Adaptation Measures and Enabling

Conditions, Climate Resilient Development. According to the report, approximately 3.3 to 3.6 billion people today continue their lives in conditions vulnerable to climate change. Current unsustainable development models increase the exposure of ecosystems and people to climate hazards. The report also notes that 11% of the global population (896 million) lived in the Low Elevation Coastal Zone in 2020, and this number is projected to reach 1 billion by 2050. Therefore, it is extremely important to transform coastal cities into resilient cities (IPCC, 2022).

Ercanlı and Savaşır (2022) address the effectiveness of floods caused by sea level rise and excessive rainfall due to climate change. They conducted their analysis as an assessment of the current situation of the city of İzmir. The study evaluates the flood risk in the coastal areas of İzmir in many dimensions and paves the way for the discussion of different scenarios.

Partigoc and Acer (2022) aimed to examine the effects of rising water levels due to climate change, which threatens coastal areas, on the built environment. The study area was selected as Kumbahçe Neighborhood in Bodrum District of Muğla Province. He analyzed the study area with the data obtained. These analyzes consist of topographical structure, hydrological features, climatic features. Thematic maps and synthesis studies were obtained as a result of the analyzes. In the light of the results obtained, possible future scenarios for coastal cities that have difficulty in being resilient in the face of disasters should be addressed quickly and institutions should produce policies.

Wai et al. (2022) focused on the impact of Houseboats on water quality in Tonle Sap Lake, Cambodia. In the study, it was observed that the water quality of the lake decreased as a result of the discharge of sewage and waste of the Houseboats into the lake. For this reason, it is stated that the Cambodian Government decided to move the houseboats to land. Studies have shown that the water quality of the lake has improved after the relocation. In the study, the change in water quality caused by factors such as floating houses blocking sunlight, creating shade, affecting wind and water flow is criticized. The conclusion drawn from this study is that the planning of houseboats should be planned in harmony with the environment by taking into account the environmental impacts and policies should be managed sensitively.

Kirimtat et al. (2020) discussed that smart floating cities can be designed using evolutionary algorithms. The results of two different evolutionary algorithms, Self-Adaptive Differential Evolution and Self-Adaptive Continuous Genetic Algorithm Differential Evolution are compared. In these results, it is aimed to optimize two conflicting objectives such as visual comfort and accessibility between points in the proposed smart floating city. In this optimization, four functions are considered: public areas, green areas, agricultural areas and property areas. While using these four functions, the study aims to achieve the best result with different combinations.

In Stopp and Strangfeld's (2010) study, floating buildings are considered as a solution to the need for additional housing and construction areas due to negative conditions such as future population growth and rising sea levels. Considering the physical and chemical effects of nature on floating buildings, the harmony of nature and structure is discussed. Considering the positive aspects of using alternative energy sources, new lifestyle, additional construction area, new building materials against possible problems and revitalizing abandoned industrial zones, harsh winds, waves and even freezing in winter time, as well as rusting of building materials (concrete and steel) due to pH values in the sea, algae formation and lack of systems such as energy, water and sewage have been seen and these situations pose a risk for the projects.

Çakır (2021) examined the situation of coastal capitals in the context of climate change. According to this study the majority of the world capitals are located on the coasts. Losses of life and property are also increasing in cities that are subjected to more disasters and destruction day by day. For these

reasons, climate migration is among the expected results. Stating that 79% of the world's countries have sea and ocean coasts, Çakır stated that 59% of these countries choose their capitals from coastal cities. When the sea level heights are analyzed, the fact that the capitals of some countries are below sea level also increases vulnerability. For these reasons, the effects of climate change should be taken into account and planning should be made accordingly.

Oğan and Emekli (2022) examined fragile spaces in the context of global climate change. According to the study melting of glaciers and thermal expansion lead to a change in sea level. This change brings with it the danger of coastal cities and islands being flooded. The emerging risks have led these cities to be addressed in the context of last chance tourism. Thus, it is observed that tourist demand for coastal cities has increased.

Kaypak (2012) included integrated policies in coastal areas in his study. In the study where coasts are characterized as the place where natural habitats, natural resources and human settlements meet; many problems from the rapid consumption of natural resources to climate change have led to the need to implement integrated policies in coastal areas.

Studies have shown that coastal areas are extremely negatively affected by climate change. Considering that a significant portion of the world's population lives in these areas, the situation of coastal areas should be sensitively studied in the planning of cities and climate change adaptation policies.

3. MATERIAL, DATA SOURCES AND METHODS

3.1. Material and Data Sources

Analyses of water level rise and flooding in the coastal areas of Istanbul and İzmir due to climate change are taken from Climate Central's Coastal DEM (CCCD), which was peer-reviewed and published by Kulp and Strauss in 2018. These maps were obtained by using artificial intelligence to improve the elevation data developed by NASA (Climate Central, 2023). Location names were added to the maps in order to better understand the satellite maps, which do not have the names of the locations, and to draw attention to the danger of water level increases on a district basis.

From the study published by Oğan and Emekli in 2022, the data of the cities most affected by sea level rise until 2100, including Istanbul and İzmir, were taken. The graph in this study has been revised in order to draw attention to the situation of Istanbul and İzmir, which are among the cities most affected by this sea level rise.

The data on the distribution of water level rise in the oceans between 1971 and 2018, as stated in the IPCC report, were taken and turned into a graph. Projected sea level changes between 2030 and 2100 for the cities of Antalya and Istanbul in NASA data are interpreted as a bar graph.

3.2. Methods

The impact of climate change, which is an alarming issue at the global level, on coastal areas is and will be affecting many people negatively. In the case of Turkey, although Turkey has a coastline of 8333 km in length, the number of rivers and lakes is also considerable. If we look at the ratio in the world; the coastline length of the coastal regions is around 312.000 km in total (Yılmaz and Serbest, 2005). In the light of these data, the main purpose of this study is to reveal and discuss the results of the current situation and future situation of the coastal areas affected by climate change and to offer solutions. In this context, the study focused on the impact of climate change on coastal areas by using the evaluation research method, one of the qualitative research methods. Problems arise due to climate

change in coastal areas where economic activities such as agriculture, tourism, port trade, fishing and industry are intensive. The hypothesis of the research is based on the fact that these problems can be foreseen in advance and cities can be made resistant to disasters by producing alternative solutions.

3.2.1. Climate Change and its Impacts on Coastal Areas

From the past to the present, migration, population growth, unconscious land use, industrialization, increase in energy and raw material production and increase in chemical wastes that harm nature have disrupted the natural balance. This situation has led to a number of negative situations such as decreasing biodiversity, increasing greenhouse gases, climate change, drought, air - water - soil pollution. In particular, the concept of climate change has recently become a topic of global interest (Gül et al. 2021).

According to the IPCC report, it is predicted that the temperature increase will be approximately 2.5-3°C until 2050 and this increase will increase up to 4-6°C by the end of the century. Climate change, which is one of the biggest risks faced by societies, causes undesirable natural events such as forest fires, drought, extreme weather events, rising ocean and sea levels and floods due to the increase in temperatures (As cited in Karapınar et al., 2020). From 1971 to 2018, the distribution of the observed increase in sea and ocean water levels is due to thermal expansion, ice loss from glaciers, ice sheets and changes in the volume of land water (Figure 1).

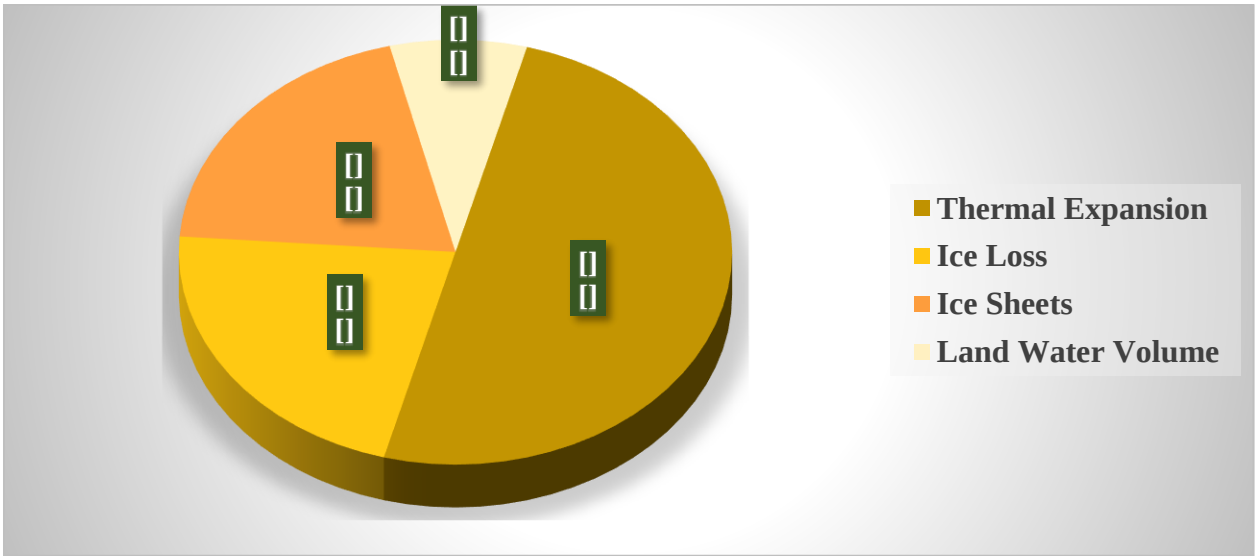

Figure 1. Distribution of Increase in Water Level (IPCC 2022)

In Turkey, Istanbul and İzmir are among the cities that may be most affected by sea level changes. The population in these cities is increasing day by day due to the multifaceted economic activities. It is estimated that the increase in water levels due to the predicted climate change will cause property problems and forced migration in these regions. This situation will greatly damage the national economy and, in the absence of planning, may lead to a change in the structure of the cities receiving migration (Figure 2).

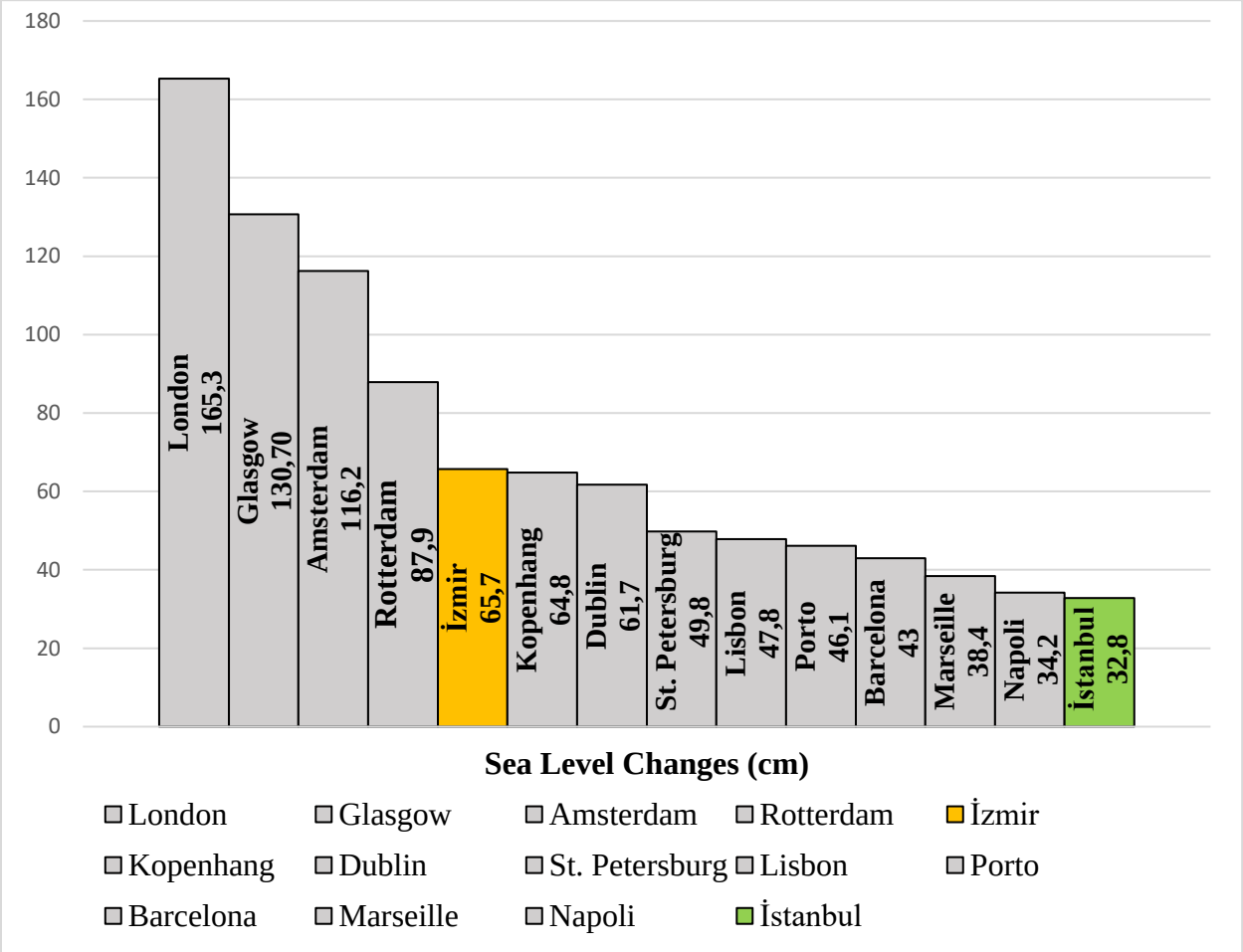

Figure 2. Coastal Cities in the World Expected to be Most Affected by Sea Level Changes in 2100 (Oğan and Emekli, 2022)

NASA has created a Sea Level Projection tool based on the IPCC 6th Assessment Report (AR6). The tool shows both global and regional sea level rise due to temperature increase according to future IPCC scenarios from 2020 to 2150. With this projection tool, sea level change estimation in İzmir-Menteş and Antalya is also included (Figure 3 - Figure 4). According to the IPCC report, SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, SSP1-2.6 Low Confidence and SSP5-8.5 Low Confidence scenarios are considered. The scenarios are ranked from very low greenhouse gas emissions to very high greenhouse gas emissions (NASA, 2023).

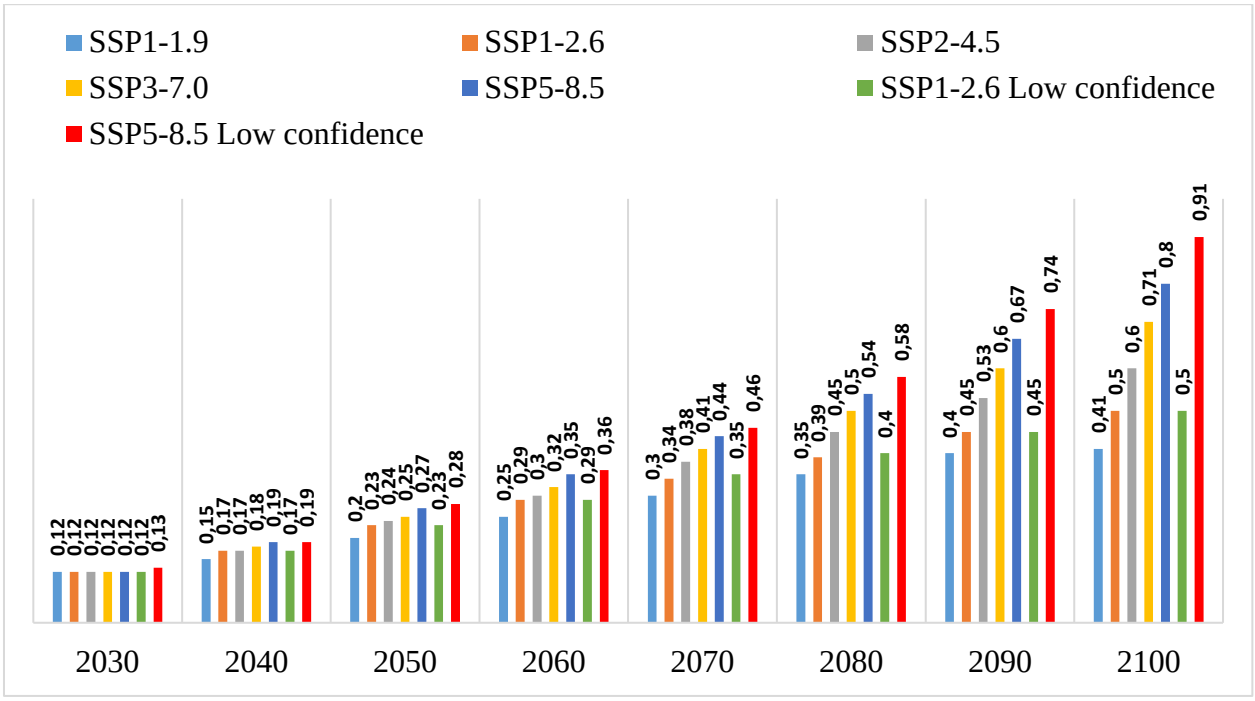

Figure 3. İzmir-Menteş Sea Level Change (m) for 2030-2100 (NASA, 2023)

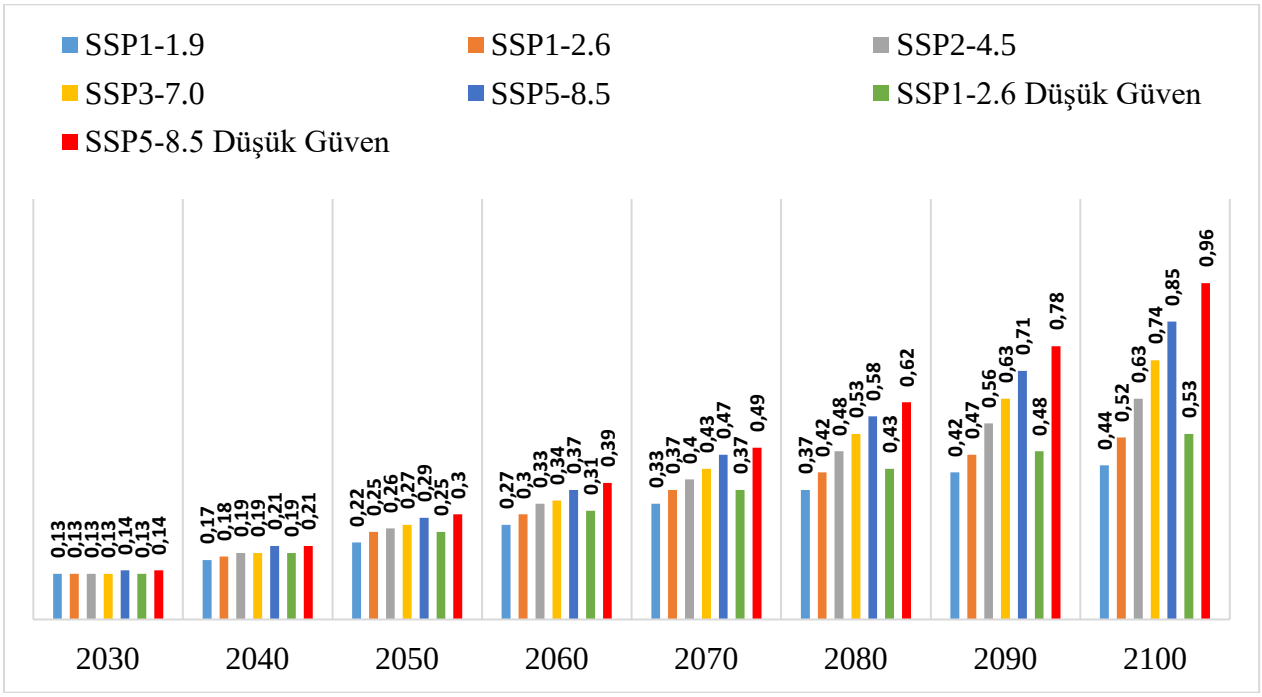

Figure 4. Antalya Sea Level Change (m) in 2030-2100 (NASA, 2023)

From the past to the present, the desire to benefit from sea transportation, to be in industrial and trade regions, and to live in temperate climates has led people to coastal cities. This situation has accelerated population growth in coastal areas and contributed to the development of coastal cities with the establishment of ports. Although water reminds people of cleanliness, beautiful landscapes and life, it also causes negative situations such as floods and erosion.

With the rise in sea level, wind and storm waves are expected to increase and this increase is expected to negatively affect transportation in coastal areas (Demir and Şahin Rodopoğlu, 2023). In addition,

sea level rise threatens the infrastructure required for living spaces and industrial zones in coastal areas, such as flooding of agricultural areas and damage to crops. Examples of these are roads, subways, bridges, sewerage areas, treatment plants, garbage areas (Lindsey, 2022). As sea level rise continues, countless people will be forced to migrate from coastal areas.

In addition, this danger in coastal areas brings along the problem of property ownership. Sea level rise in coastal areas will cause floods and the property rights of the people living in that area will be damaged by flooding. It is unclear what will happen to the property rights that will be damaged in disasters. In order to prevent this, states prepare emergency action plans based on property rights after disasters.

In Tuvalu, an island country, the sea level rises by 0.5 cm every year due to climate change. The highest point of Tuvalu Island is 4.6 meters above sea level (Önen, 2022). The fertile lands of the Tuvalu state and the immovable properties owned by the citizens are flooded. The government of Tuvalu is struggling in the international arena on what will happen to the lost rights and the policies to be implemented against the possibility of the country being completely submerged.

With the change in sea level and the inundation of settlements and agricultural areas in coastal areas, the property problem will also be seen in Turkey. It is predicted that certain districts of Istanbul and İzmir will be particularly affected. With the maps obtained from the CCCD program, it was examined whether the coastal areas of Istanbul, İzmir and Antalya would be inundated by 40 cm, 1 m and 3 m increases in water level (Figures 5, 6 and 7).

Figure 5a. Areas in Istanbul that will be inundated as a result of 40 cm rises in water level, respectively, are indicated in blue (Climate Central, 2023).

Figure 5b. Areas in Istanbul that will be inundated as a result of 1m rises in water level, respectively, are indicated in blue (Climate Central, 2023).

Figure 5c. Areas in Istanbul that will be inundated as a result of 3m rises in water level, respectively, are indicated in blue (Climate Central, 2023).

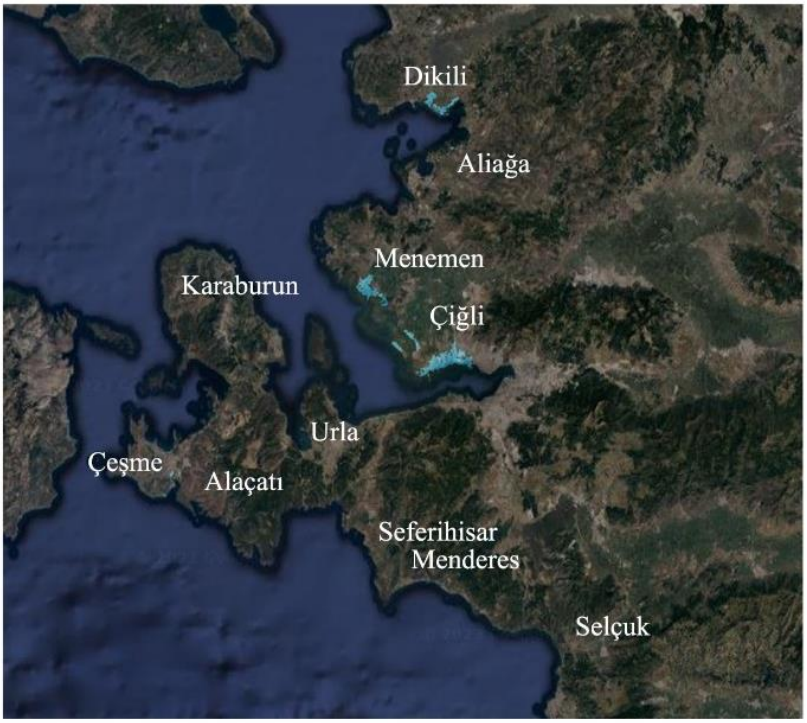

Figure 6a. Inundated areas in İzmir as a result of 40 cm rise in water level, respectively, are indicated in blue (Climate Central, 2023).

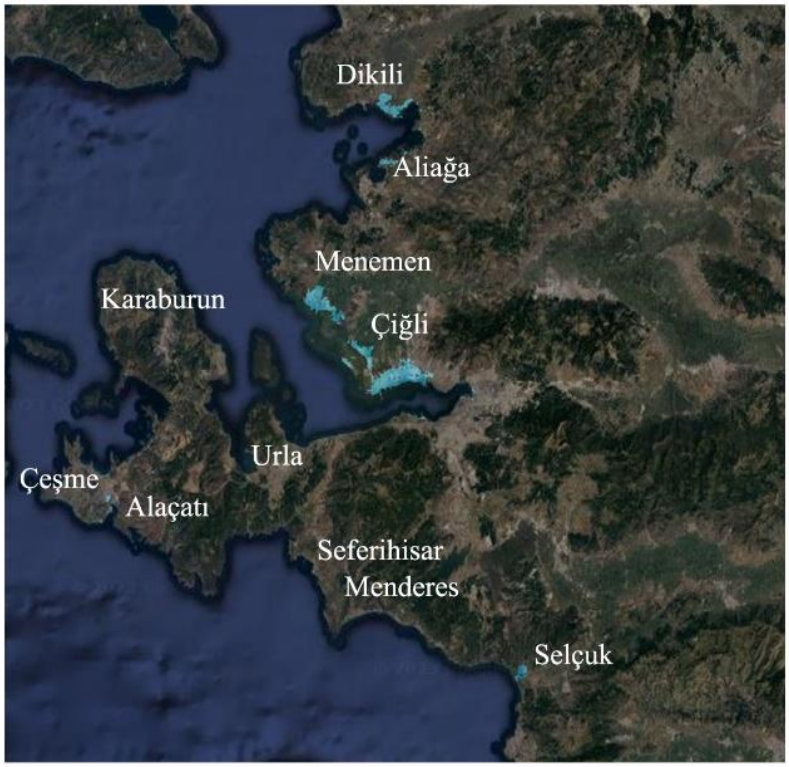

Figure 6b. Inundated areas in İzmir as a result of 1 m rise in water level, respectively, are indicated in blue (Climate Central, 2023).

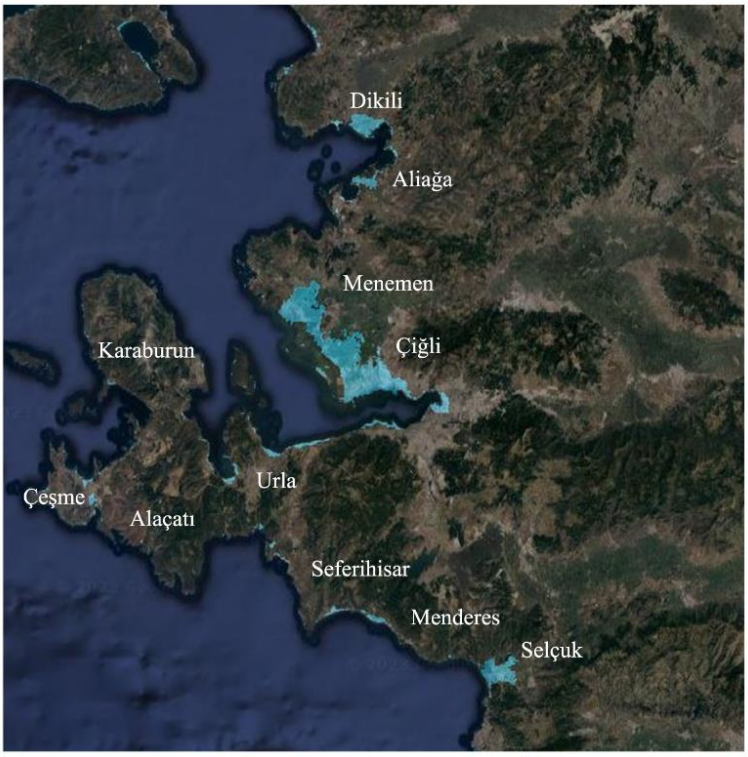

Figure 6c. Inundated areas in İzmir as a result of 3 m rise in water level, respectively, are indicated in blue (Climate Central, 2023).

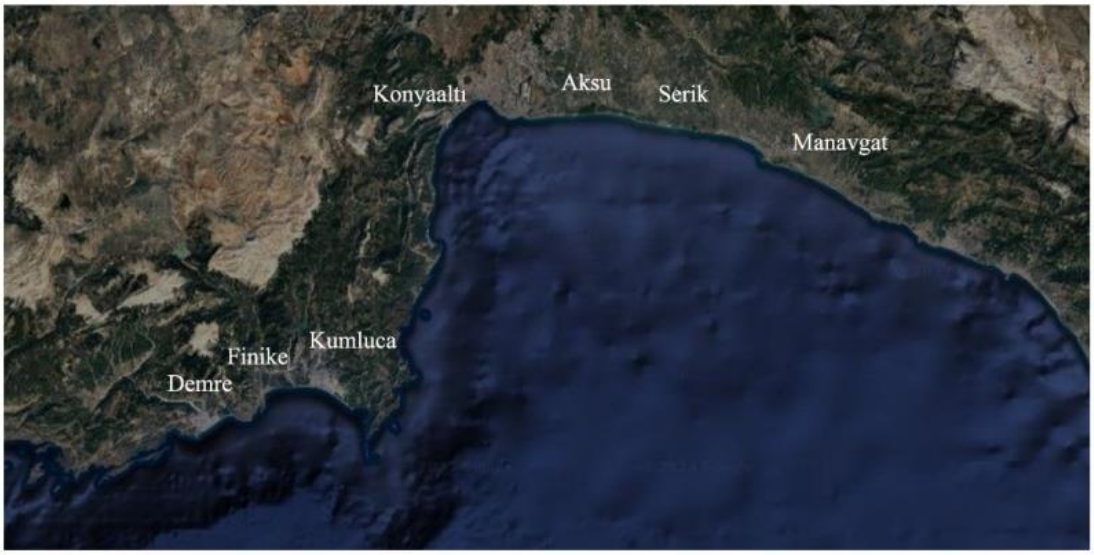

Figure 7a. Areas inundated in Antalya as a result of 40 cm rises in water level, respectively, are indicated in blue (Climate Central, 2023).

Figure 7b. Areas inundated in Antalya as a result of 1 m rises in water level, respectively, are indicated in blue (Climate Central, 2023).

Figure 7c. Areas inundated in Antalya as a result of 3 m rises in water level, respectively, are indicated in blue (Climate Central, 2023).

Maps show that as the water level rises, some of the settlements in coastal areas will be submerged, thus these areas and property ownership in these areas will be adversely affected. Therefore, this danger should be taken into consideration in the planning of coastal areas and the projects to be developed should be designed considering the impact of climate change.

3.2.2. Alternative Urban Habitat Against the Threat of Climate Change: Floating Cities

The negative factors caused by climate change, such as the increase in water level and floods that may occur in coastal areas, have necessitated the search for alternative solutions, especially on the coasts. The idea of making settlements resilient within the framework of climate change adaptation policies has led to the emergence of new living space projects. One of the most important of these projects is the floating cities project.

The concept of living on water started many years ago with fishermen living in small boats. Later, living spaces were created on the platform, which was connected to the land and could move on the water without an engine. These structures, called floating houses, have been used in many parts of the world for many years (Figure 8 a,b,c.). Amphibious houses with mechanisms that are connected to the terrestrial ground and can move 3 to 6 m vertically according to the rise and fall of the water surface are common in the USA, the Netherlands, the UK, Italy, New Zealand, Sweden, Canada, Bangladesh, the Philippines and Cambodia. Amphibious houses are preferred as a solution proposal against negative situations that may occur such as rising water levels, floods, floods, erosion, hurricanes due to climate change. Other types of floating houses, called mobile homes, are living spaces that are not connected to the terrestrial ground and move horizontally and are mostly used for fishing activities or tourism (Güner, 2019)

Figure 8a. Cambodia - Tonle Sap Lake (Anonymous, 2023a)

Figure 8b. Chile - Castro (Anonymous, 2023b)

Figure 8c. Netherlands - Rotterdam (Anonymous, 2023c)

Palafit houses built on wooden, metal or concrete piles over water are still in use today (Tavşan and Pervanoğlu, 2016). The houseboats seen in the world show collective settlement characteristics such as neighborhoods. In Turkey, on the other hand, floating houses (Figure 9) are more dispersed and suitable for aquaculture (Güner, 2019).

Figure 9. Houseboat at Keban Dam in Turkey (Güner, 2019)

Today, designers have come up with the idea of designing floating cities by bringing floating houses together. Projects such as Oceanix City and Maldives Floating City are examples of floating cities. The main purpose of these self-sufficient projects is to minimize or even prevent damage to life and agricultural areas in coastal areas due to the rise of seas and oceans due to climate change.

Introduced in 2019 at the United Nations meeting, the Oceanix City Project consists of three platforms: research, living and accommodation (Figure 10). The buildings on the platform will be between 1-5 floors, approximately 20-25 m high. The research platform is where the marine, research and temperature control center are located. The building footprint is 10,500m², the construction area is 37,000m² and the winter garden is 3,500m². The living platform includes residential buildings, local and cultural programs. The building footprint is 8,500m² and the construction area is 34,000m². The

accommodation platform includes guest rooms, a greenhouse and organic food. The building footprint is 6,500m² and the construction area is 30,000m². These three platforms are connected to each other by bridges and spread over larger areas. Thus, it has the potential to accommodate more than 100,000 people (Oceanix, 2022).

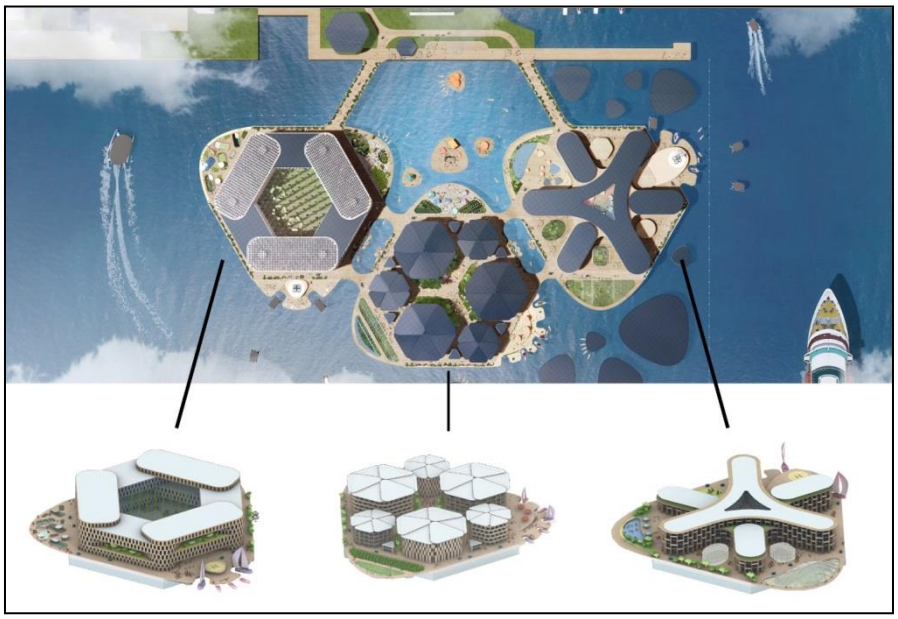

Figure 10. Research, living and accommodation platform (Oceanix, 2022).

Oceanix Cityv (Figure 11), planned to be built in Busan, South Korea, aims to implement sustainable development goals in many areas such as rainwater collection, cleaning, storage, use of solar and wind energy, recycling of fertilizers and waste, and food production based on plants and fish. The buildings in this city will be built on a floating platform and in a hexagonal modular system made of lightweight building materials such as wood or bamboo, designed to withstand wind and wave intensity. According to the calculation of wind and wave intensity, the city will be anchored to the ocean floor at certain points (Oceanix, 2022).

Figure 11. Distribution of Oceanix Floating City on water (Oceanix, 2022).

According to the IPCC Sixth Assessment Report 2022, rising water levels due to temperature rise will adversely affect living spaces in small island nations such as the Maldives. In order to prevent this situation, the Maldives Government and Waterstudio and Dutch Docklands companies have designed a floating city project concept inspired by the shape of brain coral, which will accommodate approximately 20,000 people on a 200-hectare lagoon near Male, the capital of the country. (Figure 12) In this project called Maldives Floating City (MFC), approximately 5000 low-rise buildings will be

designed, including residences, hotels, restaurants, shops, public buildings such as hospitals, schools and government buildings (Figure 13). As an alternative project to the Maldives coastal area, MFC aims to be a sustainable and self-sufficient city (Maldives Floating City, 2021).

Figure 12. Maldives Floating City (Waterstudio.nl, 2023)

Figure 13. Maldives Floating City (Maldivesfloatingcity, 2021)

Both projects aim to improve the quality of life in coastal areas against climate change. The projects planned for the sustainability of social and economic life in these areas will also increase the welfare level of the countries.

4. DISCUSSION

Sea level rise due to climate change and floods caused by excessive rainfall adversely affect coastal areas. As seen in the graphs prepared as a result of the research, sea levels are expected to rise significantly by the end of the 21st century. It is predicted that this increase will cause flooding in the coastal areas of many countries, adversely affect living spaces, cause forced migration and property problems. Therefore, the foreseeable impacts of climate change should be investigated, adaptation

plans should be made and implemented. In climate change adaptation policies, making cities resilient against disasters is important in terms of sustainable, self-sufficient cities and settlements. In 2019, with the Green Deal adopted by the EU, climate change adaptation policies were put forward, and within the framework of the policies, states have imposed responsibilities on states to take policies and measures such as making cities resistant to disasters, creating sustainable, environmentally oriented, healthy food production systems, and protecting ecosystems and biodiversity (Tuğaç, 2022b). Floating City Projects, which are considered as a solution to the search for alternative living spaces, also make a significant contribution to the creation of sustainable living spaces. For this reason, in this study, examples of floating cities at the project stage in the world were examined. The common point of the projects examined is to create a sustainable, environmentally friendly ecosystem that can produce its own energy. Today's cities have not yet been able to realize these living spaces.

Studies also show that some of the coastal areas in Turkey will be under water in the coming centuries. Maps obtained from the CCCD program show in which districts these coastal areas will be under water more. However, it is not clear how many square meters of area will be under water. If these data are made measurable, it is thought that the area and population capacity of alternative projects can be determined according to numerical data and the studies can be more reliable.

5. CONCLUSION

In this study, in which the impact of climate change on coastal areas and coastal property is investigated; it has been revealed by international scientific studies that the continued rise in the water level in coastal areas will cause infrastructure problems in coastal areas and flooding of settlements and agricultural areas. According to the results obtained with graphical and map data; it is predicted that the economic activities and settlement areas of countries will be negatively affected by climate change-induced problems such as sea level rise.

Again, the situation of immovable properties that will remain in the area of prohibition of construction as a result of the changing coastal edge line due to climate change is also uncertain. In Turkey, which is surrounded on 3 sides by the seas, coastal legislation occupies a very important place. According to Article 43 of the Constitution of the Republic of Turkey, it is stated that the coasts are under the sovereignty and savings of the State of the Republic of Turkey. It is predicted that the coastal edge line will change with the rise of the water level. At this point, with the changing coastal edge line, the problem of ownership will also arise in the areas under the sovereignty and savings of the State.

Seas and oceans are being filled to create new areas in coastal areas and to find alternative solutions to property problems due to increasing population and for tourism purposes. These filling areas threaten marine life and oceans, and also fail to prevent rising water levels, erosion and flooding. Despite the negative scenarios, care should be taken in the policies to be implemented especially in coastal areas. Climate change adaptation policies should be implemented and plans should be made to make cities resilient. Making cities disaster resistant, planning alternative living spaces, taking steps in accordance with sustainable environmental policies will contribute to making cities livable against the negative effects of climate change.

The Floating Cities project, which we see examples of in many coastal countries against the threat of rising water levels, can be considered as a solution proposal in terms of making living spaces sustainable. In many countries, floating houses are encountered for shelter purposes. However, in our country, they are used for fishing purposes. Considering the scenarios envisaged for Istanbul, İzmir, Antalya and other coastal cities, planning Floating Cities projects as an alternative living space for Turkey will be solution-oriented. These settlements to be built on water should be sustainable, self-sufficient, ecologically friendly cities that do not threaten ecological life, use sustainable building

materials, give importance to renewable energy, and are environmentally friendly by recycling waste. It is thought that the solution proposals produced against negative scenarios for coastal cities and giving importance to sustainability are also very important in terms of creating alternative living spaces and resilient cities.

Compliance with Ethical Standard

Conflict of Interest: The authors declare that they have no conflict of interest.

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EXTENDED SUMMARY

Climate change, the impact of which we feel today, is one of the most discussed and most important global threats of the century. In order to find a common solution to the climate crisis, which poses a global danger, Climate Change, which all countries of the world are looking for solutions among the problems of the next century, is an issue that should be discussed and solutions should be offered. The aim of this study is to reveal the problems that exist in the globalizing and destructed world, especially in coastal areas, and to examine the solution proposals discussed for these problems. The destructive effect of climate change is that undesirable natural phenomena such as forest fires, drought, rising ocean and sea levels and floods, which occur with the increase in temperatures, not only adversely affect the ecosystem but also put residential areas under serious risk. They affect many areas from urban life to economy. Especially in coastal areas where various economic activities are carried out,

problems caused by climate change will hinder the economic stability of countries. In addition, these problems also make urban life difficult and prevent sustainable policies. The increase in water level due to climate change also leads to floods and creates property problems. Inundation of coastal areas also leads to migration mobility. For these reasons, climate change adaptation policies should be emphasized in densely populated cities and coastal cities. States are making efforts to minimize the destructive effects of global warming and against all these negative scenarios, policy makers are addressing climate change adaptation approaches within the scope of combating climate change. The aim of global climate change adaptation policies is to make cities resilient against the impacts of climate change. For this reason, both national and international meetings discuss the situation of cities for the coming years and propose solutions. These solutions consist of making cities resilient against disasters as well as alternative urban living spaces. Turkey is among the countries in the risk group in terms of the destructive effects of global warming.

Coastal areas are densely populated areas as they host various economic activities together. Many studies show that coastal areas are one of the areas where climate change is felt the most. The rise in sea level due to climate change, especially in coastal cities, is a cause for concern. According to IPCC 2022 data, sea levels will rise between 40 centimeters and 1 meter by 2100. It is important to take action within the scope of climate change adaptation policies and to make our cities disaster-resilient.

In both national and international meetings, solutions for the future of cities are discussed. From making cities resistant to disasters to offering urban life alternatives, various discussion topics come to the fore. One of these discussion topics is floating cities. These projects, which aim to make urban life sustainable, are important in terms of reducing the risk in coastal cities and making them resilient. The concept of living on the water started years ago with fishermen living in small boats. Small boats have been replaced by living spaces on a platform that can move on water without an engine and can be connected to land. These living spaces, which are used in many parts of the world, some on wooden legs, some on concrete legs and some on metal platforms, are called floating houses. Today, designers have brought floating houses together and created the idea of floating cities.

Within the scope of the study, floating city projects such as Oceanix City and Maldives Floating City were analyzed. The main purpose of these projects is to minimize or even prevent the damage to life and agricultural areas in coastal areas due to the rise of seas and oceans due to climate change. Oceanix City consists of a proliferation of floating platforms where research, accommodation and production are carried out. The buildings, ranging from one to five storeys, will be built on the platform in a hexagonal modular system of lightweight building materials such as wood or bamboo, designed to withstand wind and wave intensity. The project aims to implement sustainable development goals in many areas such as rainwater collection, cleaning and storage, use of solar and wind energy, recycling of fertilizers and waste, and food production based on plants and fish. According to the IPCC Sixth Assessment Report 2022, in order to minimize the negative impact of rising water levels on living spaces, the Government of Maldives is collaborating with companies to design a low-rise floating living space called Maldives Floating City (MFC), which includes residences, hotels, restaurants, shops, a hospital, public buildings such as schools and government buildings. Both projects aim to minimize the impact of climate change on coastal areas, improve the quality of life of living creatures, and ensure the sustainability of social and economic life in this area.

The effects of climate change are also felt in Turkey, which is surrounded by seas on three sides. Solutions are sought to minimize these effects, increase the sustainability of living spaces and create alternative living spaces. In particular, studies predict negative scenarios for metropolitan coastal cities such as Istanbul, İzmir and Antalya. Against these scenarios, action plans against climate change should be prepared and resilient cities should be created as alternative living spaces.