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The Multi–Disaster risk assessment: A-GIS based approach for Izmir City

Nur Sinem Partigöç *[1], **Ceyhun Dinçer** [1]

[1] *Pamukkale University, Department of City and Regional Planning, Türkiye, spartigoc@gmail.com, cdincer20@posta.pau.edu.tr*

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Abstract

Urban settlements currently face many disasters that are increasing in number and frequency every day such as floods, landslides, sea level rise, storms, drought, forest fires, etc. due to the negative consequences of global climate change caused by significantly exceeding the carrying capacity of nature. Cities are currently becoming less resistant to disaster risks because of the unhealthy settlements. These settlements are becoming widespread in terms of physical, economic and social conditions as a natural result of the urbanization in which planning processes are carried out in an uncontrolled and unsupervised manner. This situation makes it a necessity to develop strategies and policies aimed at reducing and/or eliminating possible disaster damages which are defined as high risk. From this viewpoint, the study aims to reveal the current disaster risks in urban areas with a dense population and building stock. Izmir city is determined as the study area. Spatial analyses are performed for disaster risk by using Geographical Information Systems (GIS) tools and Weighted Overlap method considering the natural and built environment elements that significantly affect the disaster risk. The findings obtained from the study and the determinations made within the scope of the Izmir Provincial Disaster Risk Reduction Plan (IRAP) prepared by the Disaster and Emergency Management Presidency (AFAD) are evaluated comparatively. As a result, it has been seen that the determinations put forward for disaster risks have shown consistency throughout Izmir city and the studies carried out at the local level have been prioritized in such a way as to be aimed at risk management and prevention planning by the time.

1. Introduction

Urban growth and rapid urbanization are among the most interesting issues on a global scale. According to the UNHABITAT report [1], 52% of the world's population (3.6 billion people) lives in cities currently and the urbanization rate is projected to increase to 67% in the year 2050. Moreover, it is reported in the same report that the urban population ratio will reach 64% in less developed and developing regions. While considering that Türkiye is one of the developing regions, it is obvious that urbanization will gradually increase and the concept of urban sprawl will pose a problem in the country. In the report published by the United Nations [2], the population density has been increased from 27.6 people/km^2 to 102.2 people/km2 per 1 km^2 between the years 1950 - 2020 and also the population of urban areas has quadrupled in the period of about 70 years in Türkiye.

Disasters are among the most important social and environmental problems in the urbanization processes [3, 4]. The main common feature of disaster can be shown as the leading motive. Disasters affect negatively the urban life and citizens suddenly and the hemorrhage may occur within the loss of life and property as well as large-scale economic and social losses. Disasters have occurred throughout the human history and have formed an important agenda in every period. Therefore, they have led to serious destruction due to rapid urbanization and negative outputs of urban facilities since the beginning of 20th century. Definite natural disaster examples can be listed as the famine occurred in India in 1900 and the USSR in 1921, the floods occurred in China between the years 1928 – 1939, the volcano eruption occurred in Colombia in 1985, the Kobe earthquake occurred in 1995. Besides, the poisoning of thousands of people by chemicals in India in 1984, the tsunami occurred after the Töhoku earthquake in 2011, and the leak at the

Fukushima nuclear power plant are anthropogenic disaster examples [5, 6].

Urban settlements currently face many disasters that are increasing in number and frequency every day such as floods, landslides, sea level rise, storms, drought, forest fires, etc. due to the negative consequences of global climate change caused by significantly exceeding the carrying capacity of nature. The flood risk differs due to the local characteristics and dynamics of each city and also its frequency and impact are increasing. Actually, the floods occur and negatively affect the hydrological balance in the river basins because of the intensive building stock and land use decisions taken to meet the needs of the growing population with the acceleration of urbanization and industrialization. The interventions to natural areas referring to the built environment applications are made without considering the conservation-use balance and this situation significantly increases the disaster risk especially in urban settlements.

From this viewpoint, the study aims to reveal the current disaster risks in urban areas with a dense population and building stock. Izmir city is determined as the study area. Spatial analyses are performed for disaster risk by using Geographical Information Systems (GIS) tools and Weighted Overlap method considering the natural and built environment elements that significantly affect the disaster risk. The findings obtained from the study and the determinations made within the scope of the Izmir Provincial Disaster Risk Reduction Plan (IRAP) prepared by the Disaster and Emergency Management Presidency (AFAD) are evaluated comparatively. As a result, it has been seen that the determinations put forward for disaster risks have shown consistency throughout Izmir city and the studies carried out at the local level have been prioritized in such a way as to be aimed at risk management and prevention planning by the time.

2. The National and International Studies to Reduce Disaster Risks

Türkiye has a in a strategic position that is often exposed to natural disasters due to its geological, meteorological and topographical features. Among many disasters, earthquakes, landslides, floods, rock falls and avalanches are disaster types that the country has to cope with and take precautions. When the disasters are examined that occurred between the years 1980 - 2021, it is observed that an average of 6-25 people per one million people lost their lives due to natural disasters in each year in Türkiye. The country ranks fourth with 77 earthquakes in terms of major earthquakes that have occurred since the 1900s [7]. As it is known, Türkiye is one of the ‘high-risk’ countries of the world. The main reason for this determination is that disasters lead to extensive loss of life and property every five years on average.

The unhealthy settlements are becoming widespread in terms of physical, economic and social conditions as a natural result of the urbanization in which planning processes are carried out in an uncontrolled and unsupervised manner. Therefore, cities are currently becoming less resistant to disaster risks [8]. This situation makes it a necessity to develop strategies and policies aimed at reducing and/or eliminating possible disaster damages. Although the policies will differ in different scales (country, region, city, local, etc.), the priority should always be given to ensuring that the safety of life and property of citizens for reducing disaster risks.

Balamir [9] explains the concept of resilient city as “*it is a city or society that can minimize the losses suffered without losing its efficiency and productivity in the face of disasters and also maintain normal life”.* The disaster culture is explained as *“a social environment in which characteristics such as having a comprehensive level of knowledge about disasters, behavioral habits to prevent losses caused by vulnerabilities and dangers, giving a wide place to protection methods in educational processes and communication techniques are learned*.”

While the documents including strategies and policies for disaster risk reduction at the international level are examined, it is obvious that the concept of disaster risk reduction is widely adopted by non-governmental organizations, government agencies and international organizations. Many organizations consider the climate change as a direct impact on the prevalence of disasters, as well as having a much greater impact in the future. In accordance with this, efforts to recognize that disaster risk reduction and climate change are closely linked are increasing both politically and practically. The tsunami that occurred in the Indian Ocean in 2004 dramatically reminded us of the fact that residential areas are under threat of disaster risks. This awareness led to an international conference on disaster risk reduction by the United Nations in Kobe, Japan in the year 2005. This conference has initiated the process of efforts by national and international organizations to define appropriate steps for disaster risk reduction [10].

The Hyogo Framework Action Plan is the first accepted internationally for disaster risk reduction studies. It has been emphasized that information, innovation and education should be used for the culture-making process of security and resilience in this plan at all scales. Five priority action plans have been identified within the scope of the Hyogo Framework Action Plan: (1) the determination of national and local priorities for disaster risk reduction, (2) the identification, assessment, monitoring of disaster risks and the development of early warning systems, (3) the usage of information, innovation and education in the process of designing a responsive society, (4) the reduction of key risk factors and (5) the preparation for effective response to disasters [4].

The Sendai Disaster Risk Reduction Framework, as a second international policy guide, is prepared by the United Nations Disaster Risk Reduction Office and includes the basic issues regarding the disaster risk management between the years 2015 - 2030. This document emphasizes that the urban investments for disaster risk reduction should come to the fore as a priority step in order to increase residential areas’ resilience. Besides this, there exist other important issues highlighted by this report such as determining the guidelines for disaster risk reduction, setting action priorities, defining the roles of stakeholders with different levels of authority and responsibility, strengthening international cooperation and global partnership, providing financial support to financial institutions, etc. [2].

In addition to international policy guides, significant reports and applications are examined which contain strategies and policies for disaster risk reduction at the national level. Among many reports and applications, 8th Development Plan (2001-2005), 9th Development Plan (2007-2013), Integrated Urban Development Strategy and Action Plan (KENTGES), Law No. 6306 and Spatial Plans Construction Regulation emphasize not only the disaster risks posing a threat to residential areas, but the concept of resilience is not discussed. However, the importance of the resilient city concept has been emphasized and a wide area has been devoted to disaster risk in the National Earthquake Strategy and Action Plan (UDSEP) (2012-2023) and 10th Development Plan (2014-2018).

The mentioned reports are comparatively analyzed. In accordance with this comparison, it is seen that the 8th Development Plan is a plan that makes a full self-assessment in the closest period to the Düzce earthquake and emphasizes the effort to produce solutions. Although the concept of resilient city is not included in this plan report [11]. It is only emphasized that the decoupling of interagency authority and responsibility should be rationalized and priority will be given to the planning of regions with high disaster risk in 9th Development Plan [12]. The KENTGES Project is prepared in between the years 2007-2013 and Law No. 6306 is decertified [13]. However, the concept of a resilient city is not included and there is no emphasis on participation which indicates the development of social consciousness related disaster risks in the Law No. 6306 and Spatial Plans Construction Regulation. According to Law No. 6306, only high risky areas are identified and zoning plans for urban regeneration projects are implemented for these areas in order to reduce the disaster risk.

The concept of a resilient city has been expressed firstly in the UDSEP report (2012-2023) which has been published in the year 2011. The UDSEP report and 10th Development Plan (2014-2018) are important and strategic plans for guiding strategies in urban planning discipline. The urban planning as a tool and its role are defined in the disaster risk reduction and management processes in both documents [14, 15]. It is generally aimed to realize the earthquake-resistant, healthy and safe settlements for urban areas with these studies. The disaster volunteer system is established in the process of the participation of citizens and private sector and insurance will be encouraged for a resilient city where the earthquake problem is intense [16]. Urban planning should also be used as a principal tool in the realization of these mentioned strategies and actions. In the 10th Development Plan, the concept of disaster risk under the title of 'Livable and Sustainable Environment' is given wide publicity by emphasizing the importance of urban development and improvements. In this plan report, it is stated that studies for the disaster risk reduction are carried out due to the type of threat from micro-zoning applications for safe settlements and this issue is related to zoning planning processes in resilient cities [17]. For effective disaster risk management and resilience, it is emphasized that minimizing the disaster risks in urban generation processes, increasing social awareness and spreading earthquake risk insurance are crucial [17].

In sum, while considering that 52% of the world's population and 93% of the population in Türkiye live in urban areas today, it is clear that the possible loss of life, property and urban areas may be higher than before regarding disasters increasing in number and frequency due to global climate change. When the national and international studies to reduce disaster risks are examined, this result is an expected result. Although the awareness of the built environment's pressure on the natural environment and the implementation of decisions related to the natural environment began in the 1970s, an understanding of the disaster risks caused by the urbanization dynamics has been realized over a period of about 10-15 years. As this determination includes an important change process and opportunity in itself, it also shows the urgency of the practices that need to be implemented regarding disaster risks at the national and international levels.

3. Method

3.1. Study Area

Totally 30 districts are selected as the study areas which are located in Izmir Metropolitan city. These districts can be listed as Aliağa, Balçova, Bayındır, Bayraklı, Bergama, Beydağ, Bornova, Buca, Çeşme, Çiğli, Dikili, Foça, Gaziemir, Güzelbahçe, Karabağlar, Karaburun, Karşıyaka, Kemalpaşa, Kınık, Kiraz, Konak, Menderes, Menemen, Narlıdere, Ödemiş, Seferihisar, Selçuk, Tire, Torbalı and Urla districts. In Figure 1, the location of Izmir city within all districts defined as the study area is presented. Izmir city is located in the west part of Türkiye and is the third largest city in terms of population. The reasons why Izmir Metropolitan city is chosen as the study area are as follows:

- Its location in the earthquake zone,
- The presence of two large and active fault zones within the built environment,
- Its current geological and tectonic characteristics increasing the risk of disasters in the urbanization process,
- Different types of disasters have occurred in the historical process,
- The development of the existing built environment which is limited in a certain area due to natural thresholds within a basin,
- The suitability for settlements from a topographical point of view varies regionally,
- The settlement texture expanding towards natural areas especially the alluvial plains,
- The city is in a rapid and unhealthy urbanization process in terms of population and building density,

- The number of people per hectare is increasing due to internal migration movements and urban population growth,
- The coexistence of different types of land use such as agricultural and forest areas, low and medium density residential areas, open and green areas, etc.,
- The opening of urban open and green areas to build with partitive plan decisions,
- The rapid reduction of potential urban gathering areas which can be used after a disaster,
- The insufficiency of existing social infrastructure areas after a disaster,
- The determination that only 2426 of the total 3783 social infrastructure areas located in 388 neighborhoods in central districts (64%) are suitable, adequate and safe as a gathering area in case of disaster [18].

For Izmir city, there exist various studies in the academic literature that reveal urbanization processes have generally been handled with a partitive approach since the 17th century, great difficulties have been observed in the implementation of master plans and also the process has been managed with a mindset that there is no future prediction [19]. While the main factors are examined causing these situations, it is clear that the development processes have not been realized with the changing population and technological possibilities and plan decisions that address the needs of the city are not produced. Therefore, the lack of a planning approach that will be an alternative to the current urban land use plans is not adopted and the misunderstanding of urban regeneration processes correctly are other important determinations. Based on this point, it is possible to say that it has become quite difficult to realize a successful disaster management process in a city where the disaster risk is high, and the city is not resistant to possible disasters.

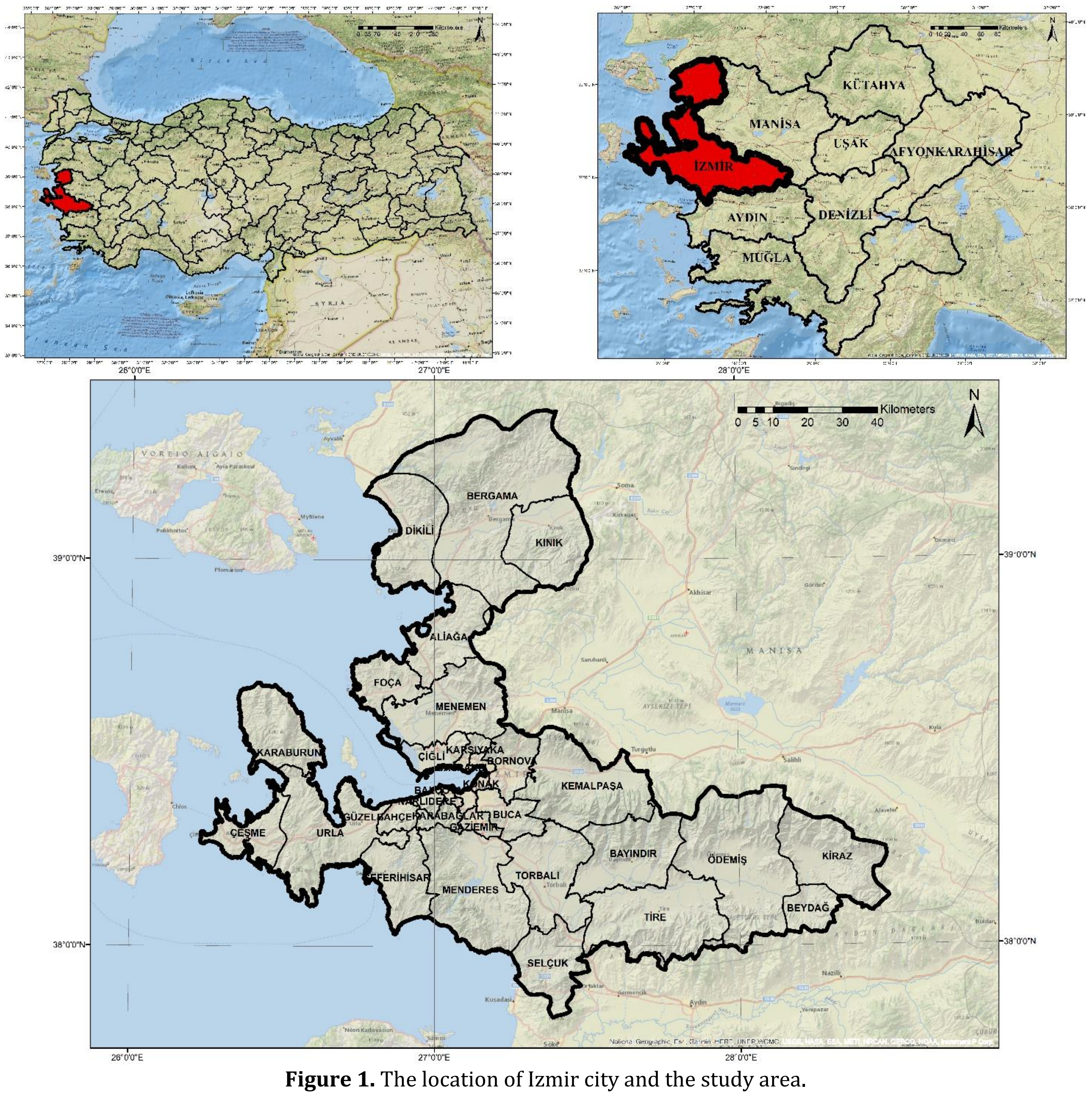

Figure 1. The location of Izmir city and the study area.

3.2. Data

Many disasters happen in Izmir city because of the geological, topographical and climatic characteristics of the city such as earthquakes, landslides, rock falls, floods, meteorological and climatic disasters, fires, industrial accidents, etc. [20]. From the point view that the entire city is at risk in terms of the direct and/or indirect effects of disasters, it is aimed to reveal the current disaster risks in Izmir city where residential settlements are located with high disaster risk. Accordingly, the parameters constituting the disaster risk are generally divided into two groups. Totally 9 parameters which are taken into account during the spatial analysis process and including the elements related to the natural and built environment are listed as:

a) Parameters related to the natural environment-> Topographic parameters (slope, aspect, elevation), meteorological parameters (temperature, precipitation amount), fault lines, hydrology, geological formation and soil ability.
b) Parameters related to the built environment-> Current land use pattern.

The thematic maps are prepared for slope (Figure 2), aspect (Figure 3) and elevation (Figure 4) within the scope of the study. These maps related to the natural environment are examined and it is found that the inclined areas with a slope value between 0 - 10%, areas with an elevation value between 0 - 300 meters and the south aspect features are concentrated in central districts of the city. When considered the built environment has been developed on the mountains perpendicular to the sea, the plains between them and the coastal area, topography is one of the most important determinants of spatial location selection in city. For this reason, it is observed that the spatial development observed around the city is not in compact form, but in the form of linear development. Actually, potential residential areas are quite limited around the central districts because of natural thresholds. In other words, the topography factor allows for very limited development in terms of new residential areas where the slope value is suitable for settlements between 0 - 10% are only 8.6% of the entire city [21]. Due to this, it can be said that the topographic parameters are the basic factors that increase the disaster risk and can affect it negatively in the study area.

The thematic maps are prepared for fault lines (Figure 5), hydrology (Figure 6), soil ability (Figure 7) and geological formation (Figure 8) within the scope of the study. These maps related to the natural environment are examined. It is found that there are totally 21 fault lines in the entire city that cause any earthquake of magnitude 6 that can trigger other disasters like tsunami (Figure 5). Therefore, according to the findings obtained from the hydrological analysis, it is found that there exist rich underground and above-ground water resources in Izmir city, especially the most important rivers (Küçük Menderes, Bakırçay and Gediz rivers). So, it is obvious that about 54% of city is located within the boundaries of the Küçük Menderes basin, 16% is located within the Gediz basin and 25% is located within the Northern Aegean basin [22] (Figure 6). The entire city and its surroundings have important disadvantages in terms of the disaster risks that the presence of water may cause depending on meteorological and climatic conditions.

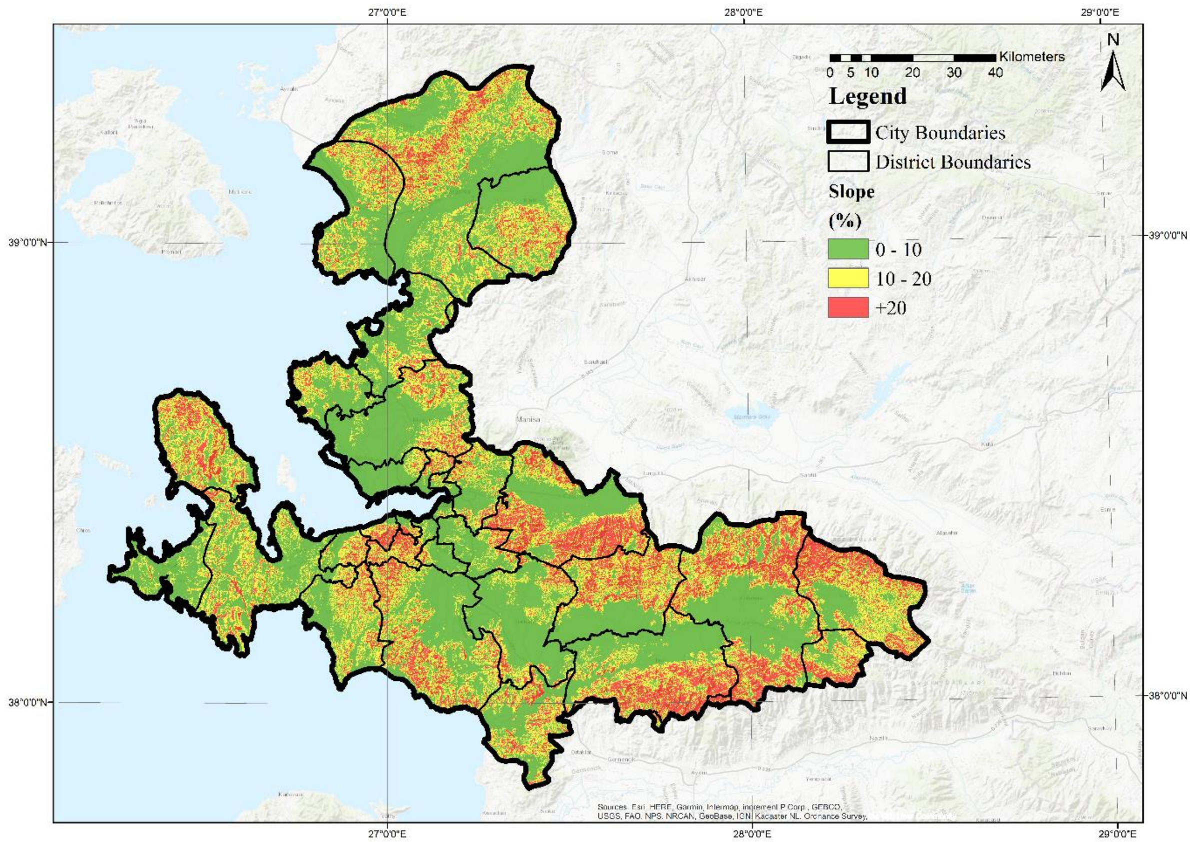

Figure 2. Slope analysis.

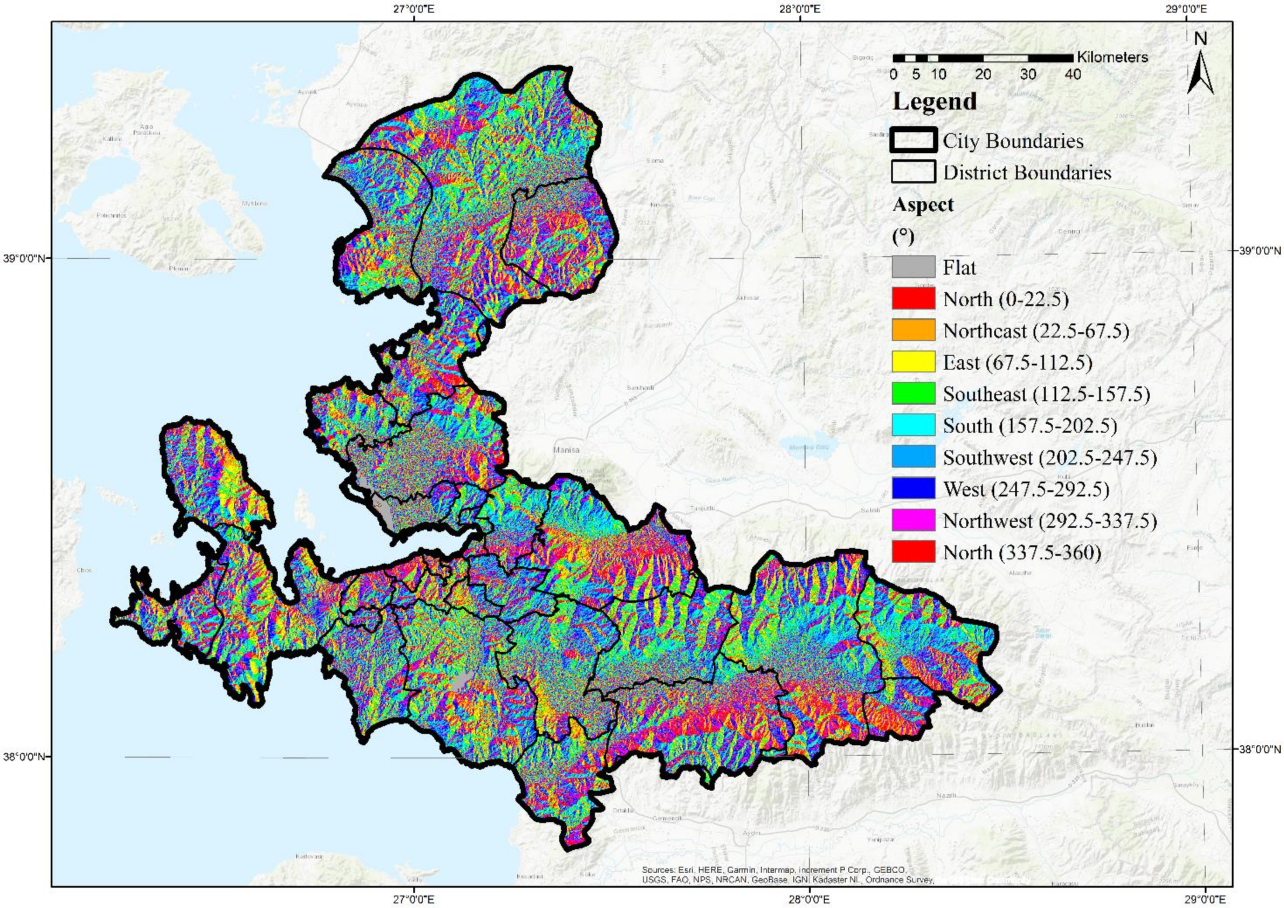

Figure 3. Aspect analysis.

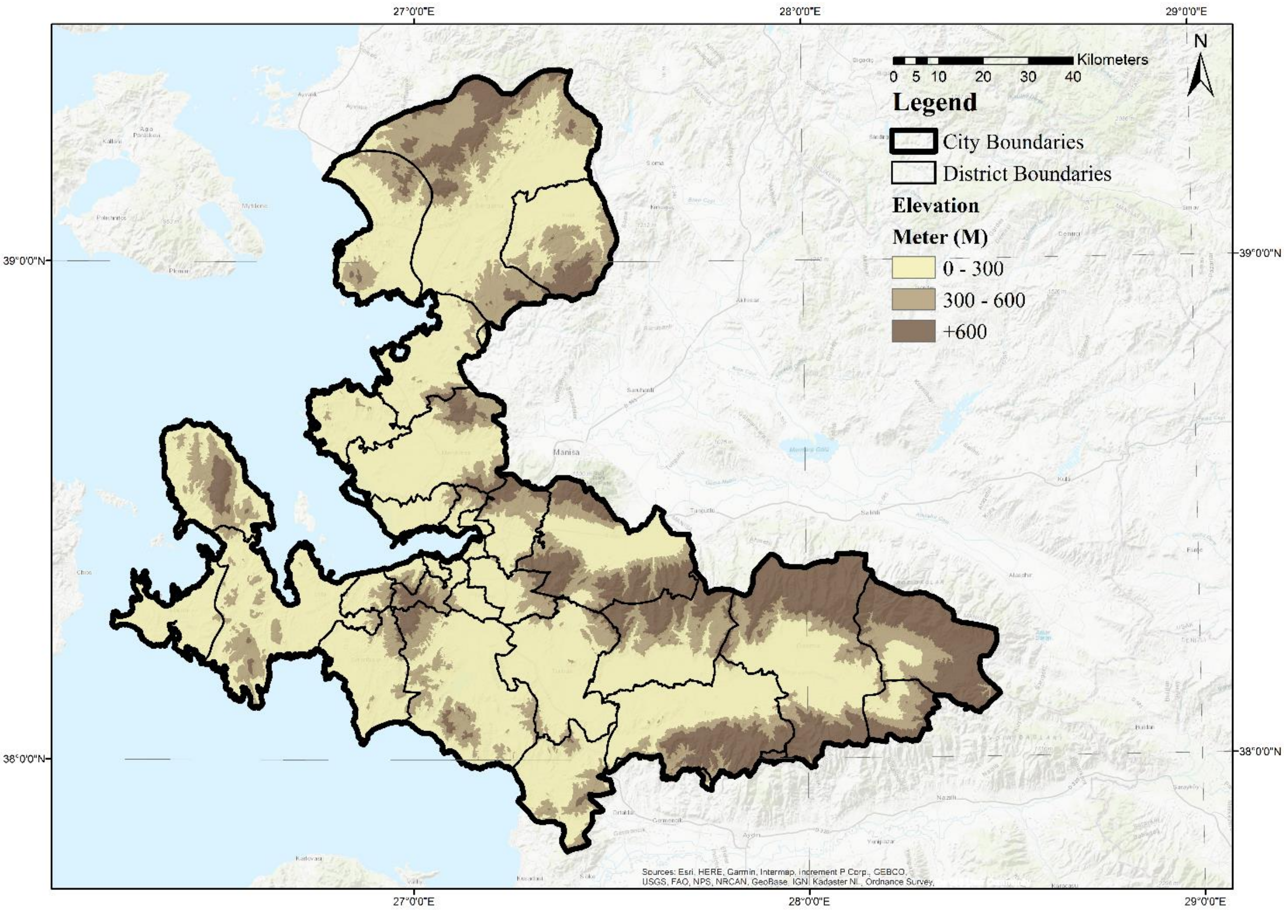

Figure 4. Elevation analysis.

Besides, according to the findings obtained from the analysis of soil ability, it is found that there are large soil groups throughout the city (alluvial soils, brown soils, chestnut-colored soils and red soils) with climatic conditions and topographical effects. The alluvial soils in the north and west parts and the red soils in the south and east parts of the central districts of city are basic factors that increase the disaster risk for landslides and floods (Figure 7). Incidentally, according to the findings obtained from the geological formation analysis, it is clear that neogene and quaternary sediments, early miocene granitoids, neogene volcanics and Izmir fluxus are mainly located throughout the entire city (Figure 8). All areas except the north-east part of the central districts are not suitable for construction due to the existing soil characteristics while these formation types are examined in terms of suitability for the settlements.

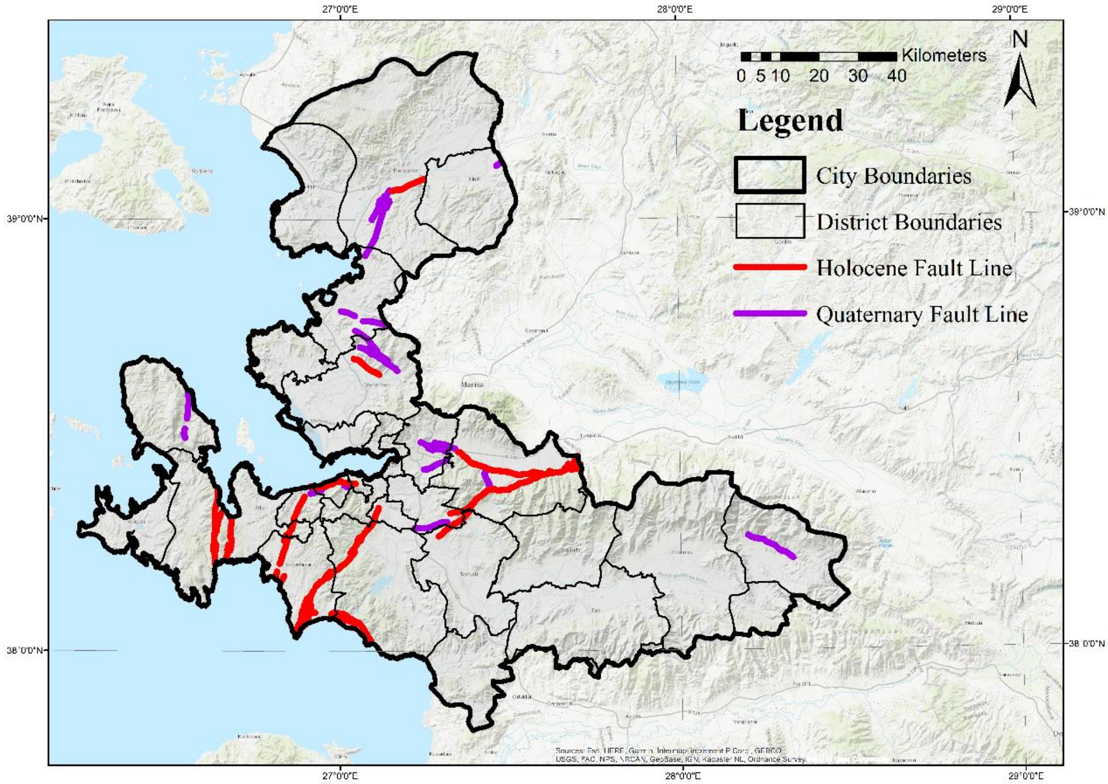

Figure 5. The fault lines' analysis.

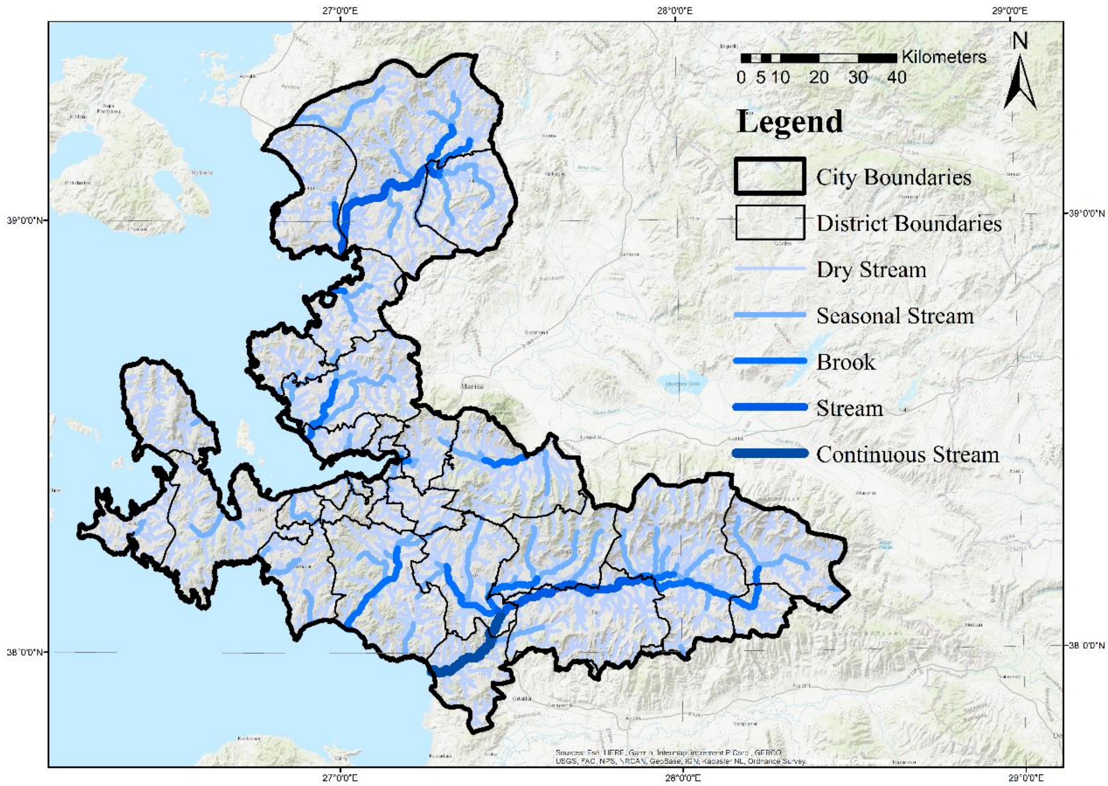

Figure 6. Hydrological analysis.

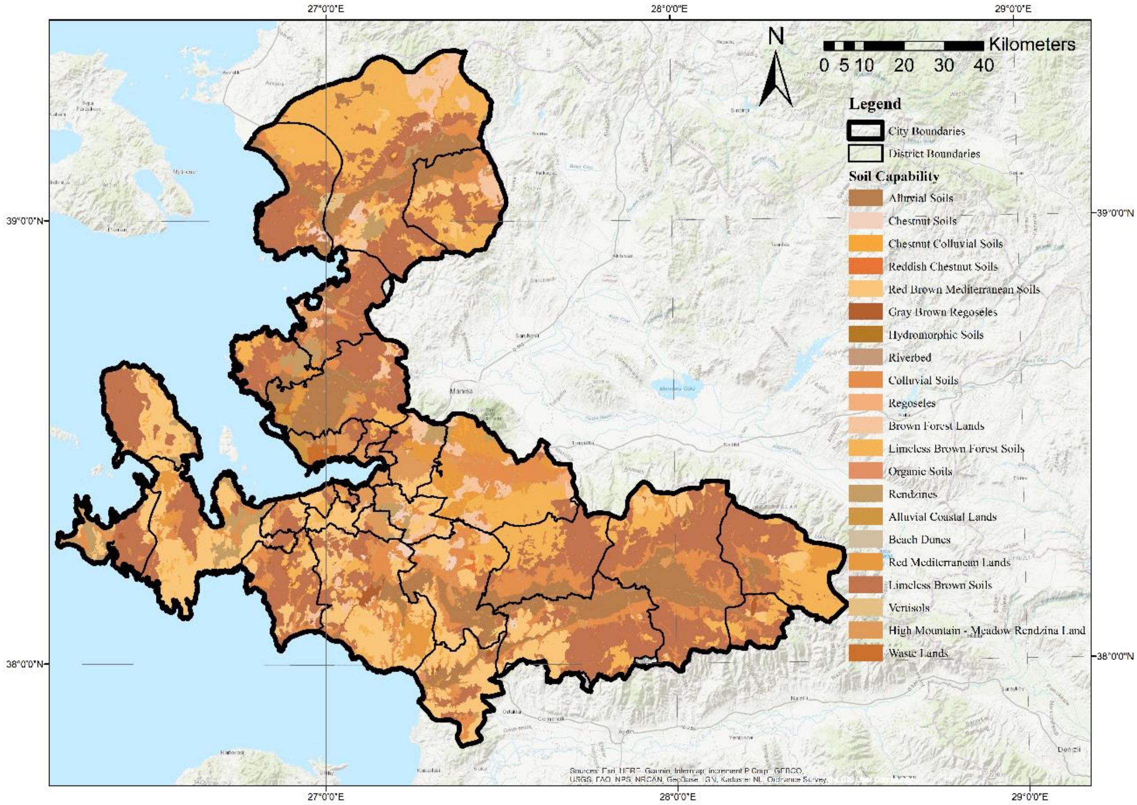

Figure 7. Soil ability analysis.

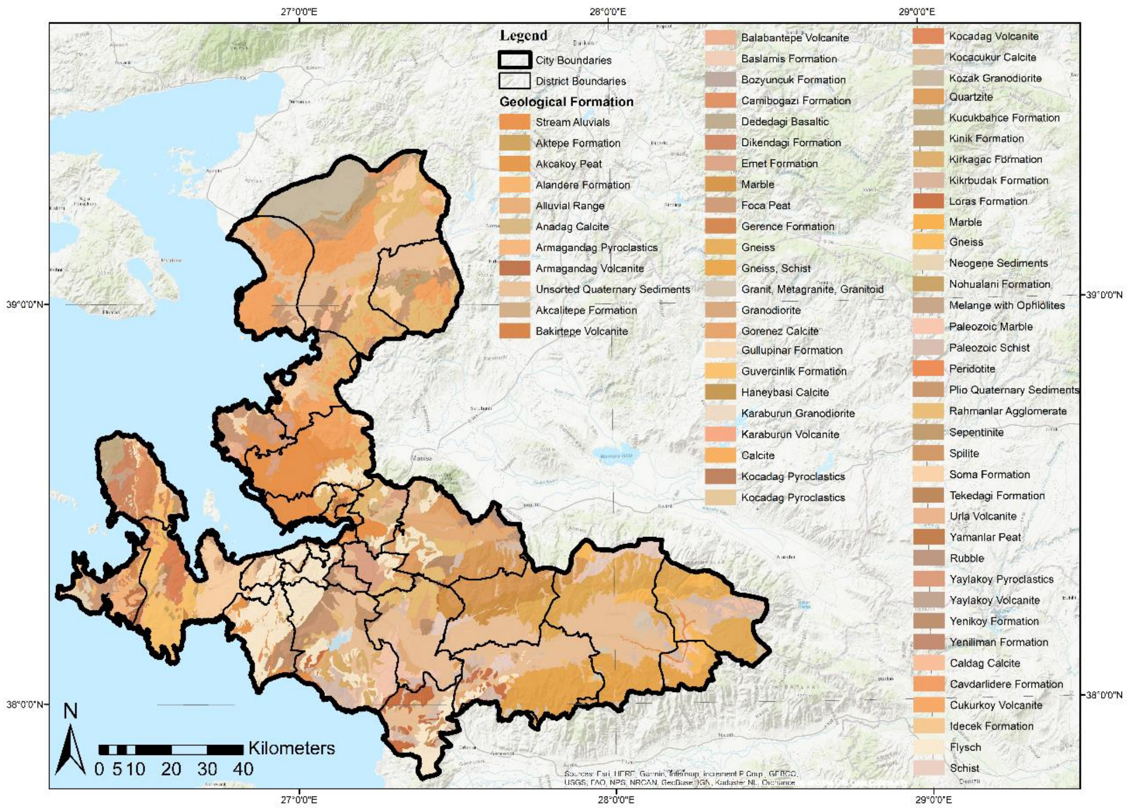

Figure 8. Geological formation analysis.

The current climatic and meteorological features are directly related to the disaster risks in urban areas. Based on this point, the thematic maps are prepared for the temperature (Figure 9) and precipitation amount (Figure 10) within the scope of the study. As well as slope, aspect, elevation, fault lines, hydrology, geological formation and soil ability, these maps related to the natural environment are examined. It is found related the temperature and precipitation amount that the average annual temperature value is 17°C and the average precipitation amount is 700 mm in the city located in the Mediterranean climate zone. As it is known, the perpendicular position of the mountains to the sea, the sea effect can reach as far inland as the plains. For this reason, the characteristics of the typical Mediterranean climate (warm and rainy in winter season, dry and hot in summer season) are monitored in the study area. Actually, there exist definite factors which increase disaster risks in urban areas such as the rainy season lasting for about 6 months in a year, significant differences in the precipitation amount between summer and winter seasons, the excessive precipitation in the winter season and drought caused by low rainfall in summer season, etc. The extreme precipitation events observed outside the seasonal norm cause losses of life and property due to flooding in rural and urban areas and damage to urban infrastructure elements.

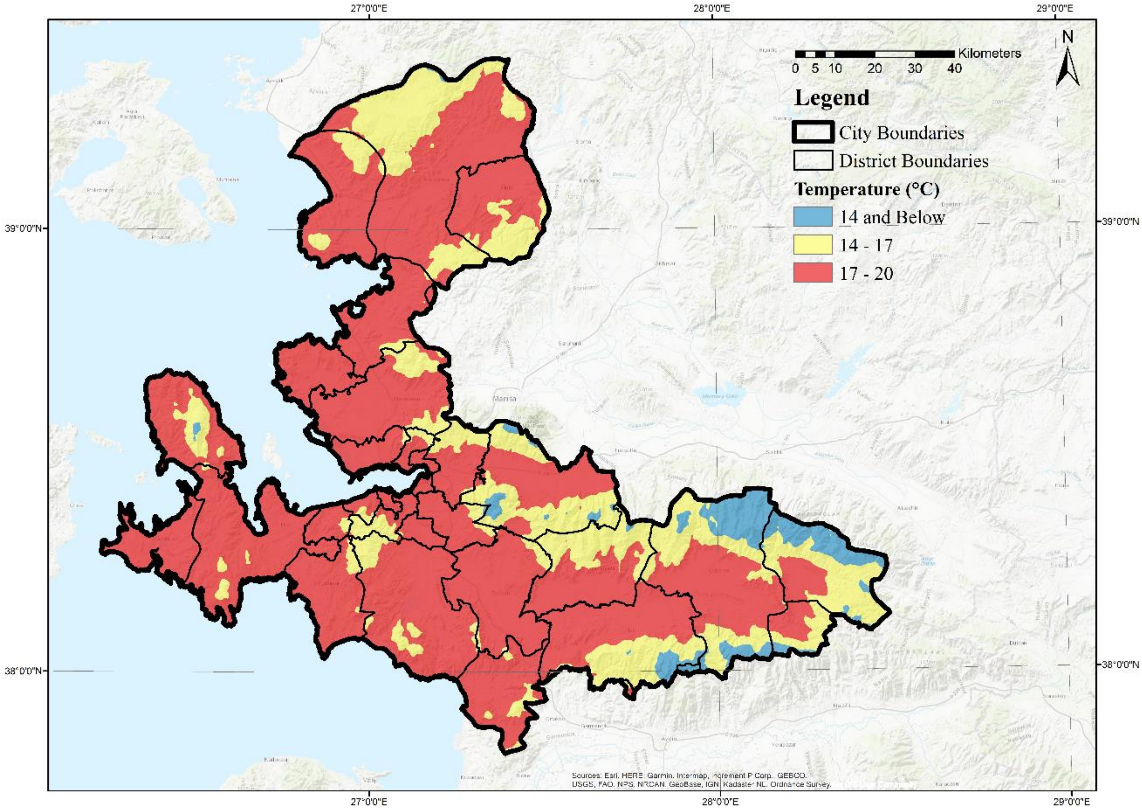

Figure 9. Temperature analysis.

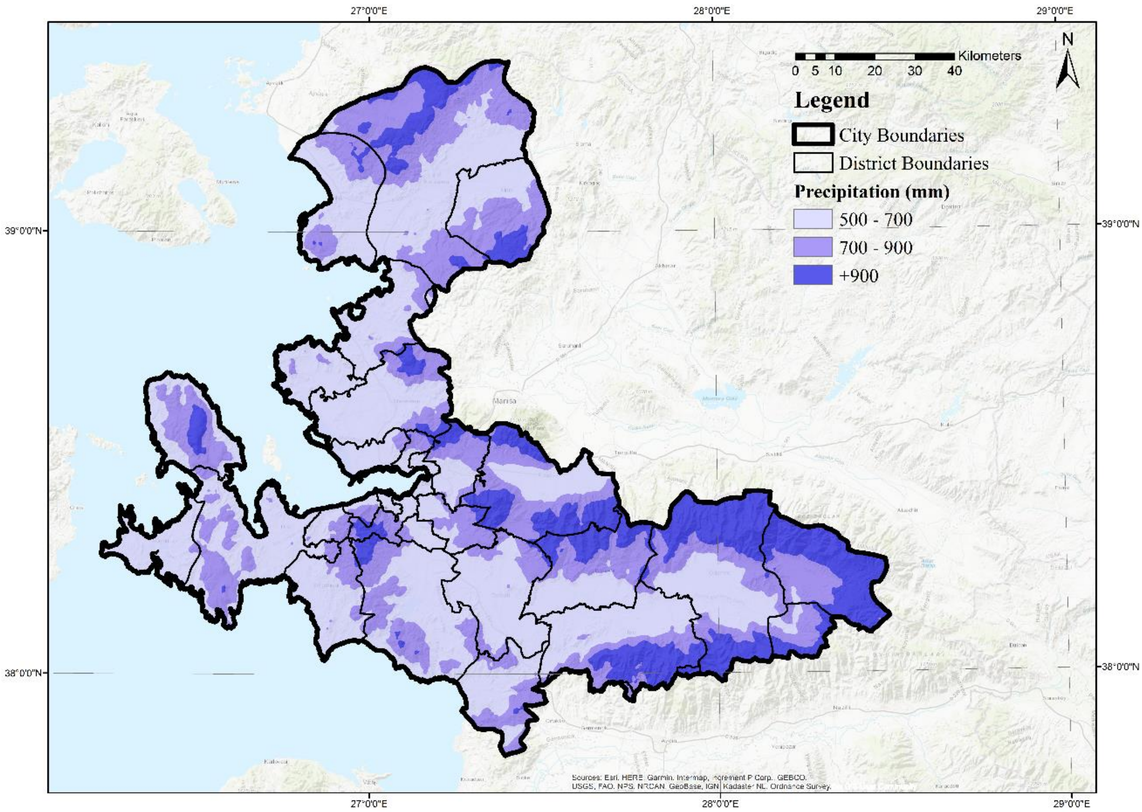

Figure 10. Precipitation amount analysis.

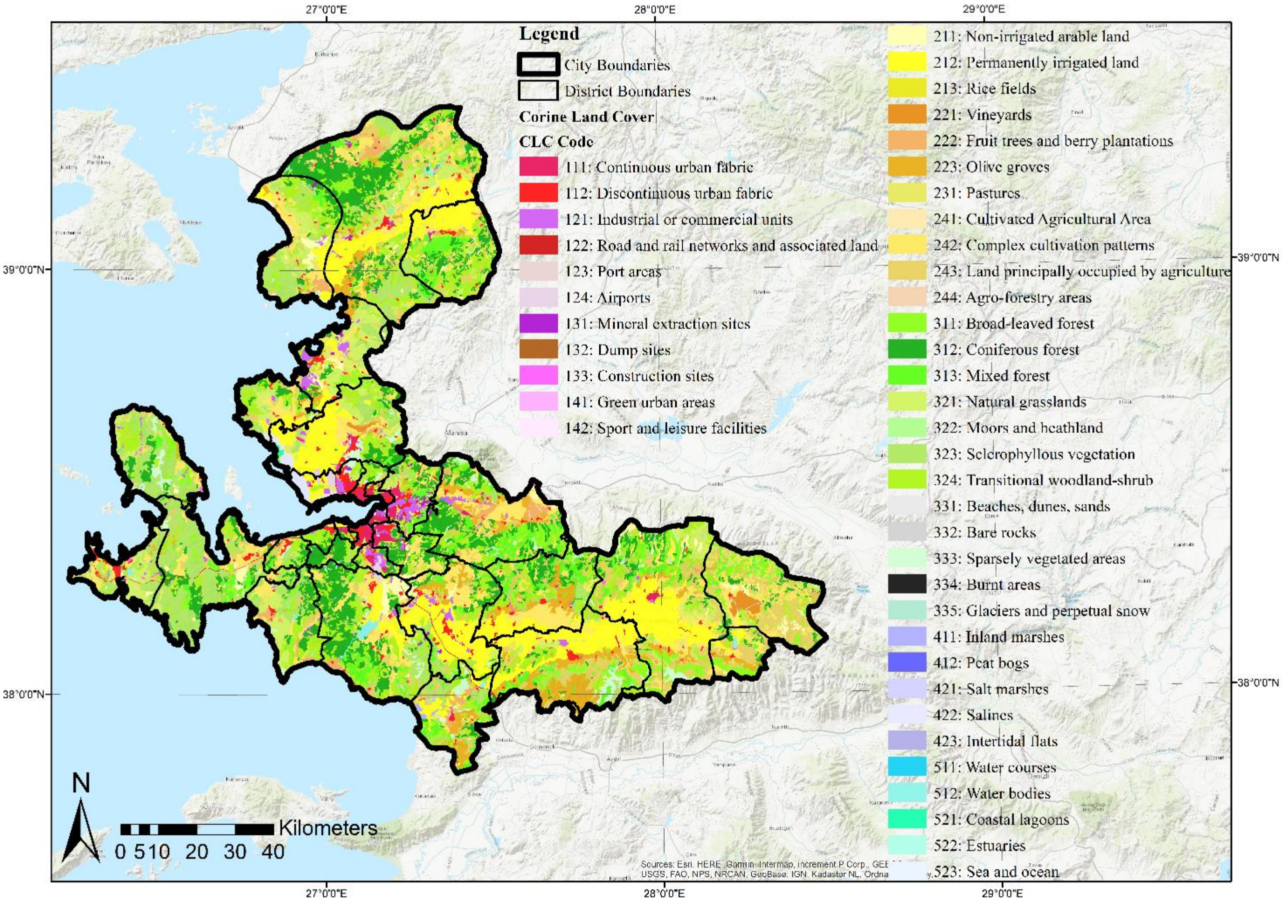

Figure 11. Thematic maps for the built environment parameters (The land use pattern analysis)

According to the results obtained by the General Directorate of Meteorology after analyzing the drought throughout the country for the period March 2022 – March 2023, Izmir city is classified in the class of very severe arid cities [23]. It is estimated that the drought observed is severe throughout the entire city and in its surroundings and the negative effects of drought will increase over time regarding global climate change. So, the study area is in a disadvantaged situation in terms of disaster risks because of facing the threat of drought.

The thematic map is prepared for current land use pattern within the scope of the study and also presented in Figure 11. This map related to the built environment is examined. It is found that forest areas (39%) and agricultural areas (33%) are the largest areas among the land use types in the entire city. As other land use types, there exist residential areas (17%), tourism areas (5.5%) and other land uses (archaeological sites, special environmental protection areas, etc.) (approximately 5.5%). Actually, important advantages are observed for the natural environment parameters such as the large area size of forest areas comparatively in land use types, residential areas constituting about 20% of the entire city, the excess of agricultural production areas providing significant economic returns, etc. Although this determination has significant risks in terms of possible disaster risks (forest fires, earthquakes, floods and drought).

The main objectives of the urban planning process include designing the built environment by considering the protection-use balance, eliminating today's needs without renouncing the needs of future generations, ensuring sustainability in social, economic and environmental dimensions. In addition, it is crucial that risk management processes are carried out correctly before possible disasters in order for citizens to live in urban areas which are healthy, safe and high quality. It is a necessity to reveal the risk related to the disaster types qualitatively and quantitatively in urban areas where the population is rapidly increasing. The idea of identifying existing risks as a priority in order to develop policies and strategies specific to disaster risk settlements has been successfully put forward with the Provincial Disaster Risk Reduction Plan (IRAP) in the period of September 2021 [20]. A similar content appears in the study named The Disaster Prevention / Mitigation Basic Plan including Seismic Micro-Zoning for the Province of Istanbul prepared by the Japanese International Cooperation Agency (JICA) and Istanbul Metropolitan Municipality (IBB) in the year 2002 [24].

Accordingly, it is aimed to conduct a comprehensive analysis of the disaster risks for the Izmir city within the scope of the study. For this purpose, one of the Geographical Information Systems (GIS) tools named the Weighted Overlay method is used. Spatial analyses are performed for 4 different disaster types (earthquakes, mass movements, floods, industrial accidents, fire, meteorological disaster and climate change, medical geological disasters, infectious diseases, etc.) in the study. These types are identified for Izmir city by the Izmir Provincial Disaster and Emergency Department taking into accounts the natural and built environment elements that significantly affect the city's resilience. The findings obtained from the study and the determinations made within the scope of the Provincial Disaster Response Plan and the Provincial Disaster Risk Reduction Plan (IRAP) prepared by the Provincial Disaster and Emergency Directorate of the Izmir Governorate is evaluated comparatively.

The Weighted Overlay method as the selected method is has been widely preferred for spatial and non-spatial studies related to disaster risks in which more than one type of disaster related to settlements has been observed. This method is applied in various studies regarding the different disaster risks (flood, landslide, earthquake, rockfall, tsunami, etc.). As examples, researches for Bitlis city [25], Malatya city [26], Istanbul city [27], Manisa city [28], Hatay city [29] and Van city [30] can be given. In addition to these, there exist many researches emphasizing the importance of disaster risk analyses in carrying out urban planning and disaster planning processes together [31-35] in the academic literature.

A database including current data has been constituted via ArcMap software. Using the mentioned database, the following steps are followed in the study:

1. The digitization of the natural and built environment parameters (slope, aspect, elevation, temperature, precipitation amount, fault lines, hydrological structure, soil ability, geological formation and land use pattern),
2. The controlling of coordinate systems of data layers,
3. The classification of parameters according to their features,
4. The transferring spatial and non-spatial features to thematic maps,
5. The determination of the weights of the parameters that pose a risk according to the identified disaster types,
6. The synthesis of data analyzed in separate layers by overlapping,
7. The comparative evaluation of the obtained analysis results with the Provincial Disaster Response Plan and the Provincial Disaster Risk Reduction Plan.

Table 1. The classification of parameters.

Parameter	Values	Classification of Disaster Risk	Class	Weight (%)
Slope (%)	0 – 10	Less risky	1	20
	10 – 20	Medium risky	2	
	20 and above	More risky	3	
Aspect	East - West	Less risky	1	5
	South (South, South-east, South-west)	Medium risky	2	
	North (North, North-east, North-west)	More risky	3	
Elevation (meter)	0 – 300	Less risky	1	5
	300 - 600	Medium risky	2	
	600 and above	More risky	3	
Precipitation amount (mm)	500 - 700	Less risky	1	10
	700 - 900	Medium risky	2	
	900 and above	More risky	3	
Temperature (°C)	14 and below	Less risky	1	5
	14 - 17	Medium risky	2	
	17 and above	More risky	3	
Fault lines	Yes	Less risky	1	10
	No	More risky	3	
Hydrological structure	Day stream	Less risky	1	15
	Seasonal stream	Less risky	1	
	Brook	Medium risky	2	
	Stream	More risky	3	
	Continuous stream	More risky	3	
Soil ability	Brown soils	Less risky	1	5
	Chestnut-colored soils	Medium risky	2	
	Alluvial soils	More risky	3	
	Red soils	More risky	3	
Geological formation	Granitoids	Medium risky	2	15
	Volcanics	Medium risky	2	
	Sediments	More risky	3	
	Flish	More risky	3	
Land use pattern	Agricultural areas	Less risky	1	10
	Meadow-pasture areas	Less risky	1	
	Other land uses	Less risky	1	
	Forests	Medium risky	2	
	Tourism areas	Medium risky	2	
	Industrial areas	Medium risky	2	
	Transportation-infrastructure	More risky	3	
	Settlement areas	More risky	3	

The disaster risk classifications are made using the natural and built environment parameters within the scope of the study in order to make spatial analyses (Table 1). Accordingly, the parameters due to these classifications can be listed as follows: Slope, aspect, elevation, precipitation amount, temperature, fault lines, hydrological structure, geological formation, soil ability and land use pattern.

As natural environment parameters, the slope is an important factor in the formation of floods because it affects the amount of precipitation accumulated and the flow rate. The slope value is high where the water retention ability of the soil is lower in comparison to the slope value is low. In addition, the slope is among the most important factors that increase the erosion risk [36, 37]. Therefore, as the slope increases, the risk for certain types of disasters increases. The aspect is a factor that creates a disaster risk for floods, droughts and erosion. The direction of the topography differs on the northern and southern slopes. On the south-facing slopes, the loss of water in the soil due to evaporation is high, so the potential of drought increases in these areas. On the north-facing slopes, the holding capacity is low because there is too much moisture in the soil, so the risk of flooding and erosion is high in these areas. The riskiest areas are the north-facing slopes in terms of flood risk [30]. The elevation values are high where the slope increases. Streams with high flow accumulation in areas where slope values are high increase the risk of floods and erosion in these areas. In other words, where the river valley expands, the elevation values are low, the slope values and also disaster risks decrease [36].

One of the natural environment parameters given the reference to meteorological and climatic features is the precipitation amount. According to climatic features, the excessive and torrential rainfall increases the risk of erosion, flooding, especially on slopes where the slope is high and vegetation is rare in spring and winter in the semi-arid climate class. The temperature is a climate element that controls geographical conditions and life activities closely [38]. It is the most dynamic parameter that creates the climatic conditions of a place and also plays a decisive role on the living conditions of flora and fauna with its effect on the occurrence and the precipitation amount. The temperature parameter is the primary factor especially in meteorological disasters and climate change. This parameter has a direct or indirect effect on the occurrence of disasters that enable people to perform many activities or interrupt these activities [39]. As another parameter related to the natural environment, the fault lines are one of the geological features of residential areas, the degree of influencing the disaster risk varies according to the fracture length, fracture width, fracture area and surface displacement for a fault line [40]. The residential areas are disadvantaged in terms of earthquake risk while a dense population lives close to fault lines and are located in areas where there is liquefaction of the ground [41].

The hydrological structure is one of the prominent parameters in terms of the presence of underground and above-ground natural resources. Floods are a stage of the hydrological cycle and are a form of surface runoff which is one of the important types of disasters. Floods may occur from the source in river basins, geological structure of the basin, soil structure, topographical structure, climatic, etc. [42]. As a result of the construction processes into the streams and stream beds and incorrect and unplanned land use decisions, the existing waterbed turns have narrowed and natural cases turn into disasters [43, 44]. The soil ability, as another natural environment parameter, shows different susceptibility states to erosion depending on the slope condition of the land and the lithology on which it develops and the presence of vegetation. Although the soil has a resistant property on slopes where the slope is too high and devoid of vegetation, it may be subject to erosion depending on the severity of precipitation. On the other hand, the non-resistant soil structure that develops in parts where the slope is low and vegetation is frequent may be less susceptible to erosion. Brown soils are young soils that develop in sloping places and are known as steppe soils. This type of soil has a high water-holding capacity which is poor in terms of organic matter content. Chestnut-colored soils are a type of soil with an average annual precipitation of 400 mm and above, formed in meadow and oak forests, containing organic matter and can be seen in pastures in high-slope areas while they are productive enough to be farmed. Alluvial soils and red soils are among the species that increase the risk for landslide and flood-type disaster events due to their less resistant and soft-soil structures [36, 45].

According to the examination related to the geological formation parameter, it is found that neogene and quaternary sediments, early miocene granitoids, neogene volcanics and Izmir fluxus are mainly included in the study area. The formations of sediments and the flish formation are appropriate in terms of suitability for the settlements. The flish formation is very often subject to landslides during different periods and is unsuitable for construction due to the risk factor for disasters. Granitoids with gravel structure and volcanics with fragile mineral structure are partially suitable for construction due to the fact that they do not have a solid ground in terms of structural statics and safety. It can be said that the types of geological formations are a trigger factor for disaster risks for the study area that are not suitable for settlements.

As the built environment parameter, the land use pattern is selected within the scope of the study. It is an important element in the planning processes that the plan decisions developed regarding the existing land use types do not have a nature that increases the disaster risks. There exist definite areas that may cause increased losses of life and property in case of disaster and carry a high risk such as residential areas where there is a dense population and structure, industrial areas where industrial production is carried out and transportation, access, communication in urban areas, etc. Although there is no risk of loss of life and property in forest areas, meadows, pastures and agricultural areas located outside urban centers, the potential economic losses should be taken into account because of drought, fire and flood cases [18, 46-49].

According to the synthesis map reveals the disaster risk status of Izmir city in Figure 12, the districts located in the east and south parts of the city (Bornova, Kemalpaşa, Karabağlar, Gaziemir, Menderes, Bayındır and Karaburun districts) are relatively disadvantaged in terms of disaster risk. In addition, it is found that the districts located in the north, west and south-east parts of the city (Çeşme, Buca, Torbalı, Aliağa, Foça, Dikili, Bergama and Güzelbahçe districts) are more advantageous and the less risky residential areas are relatively more in these districts. Other districts can be classified as medium risk (Çiğli, Bayraklı, Karşıyaka Menemen, Konak, Balçova, Narlıdere, Seferihisar, Selçuk, Tire, Ödemiş, Kiraz and Beydağ districts). Accordingly, there is a determination for all residential areas with urban and rural characteristics throughout the city are affected by the disaster risks that can be created by 4 different types of disasters identified by the Izmir Provincial Disaster and Emergency Department.

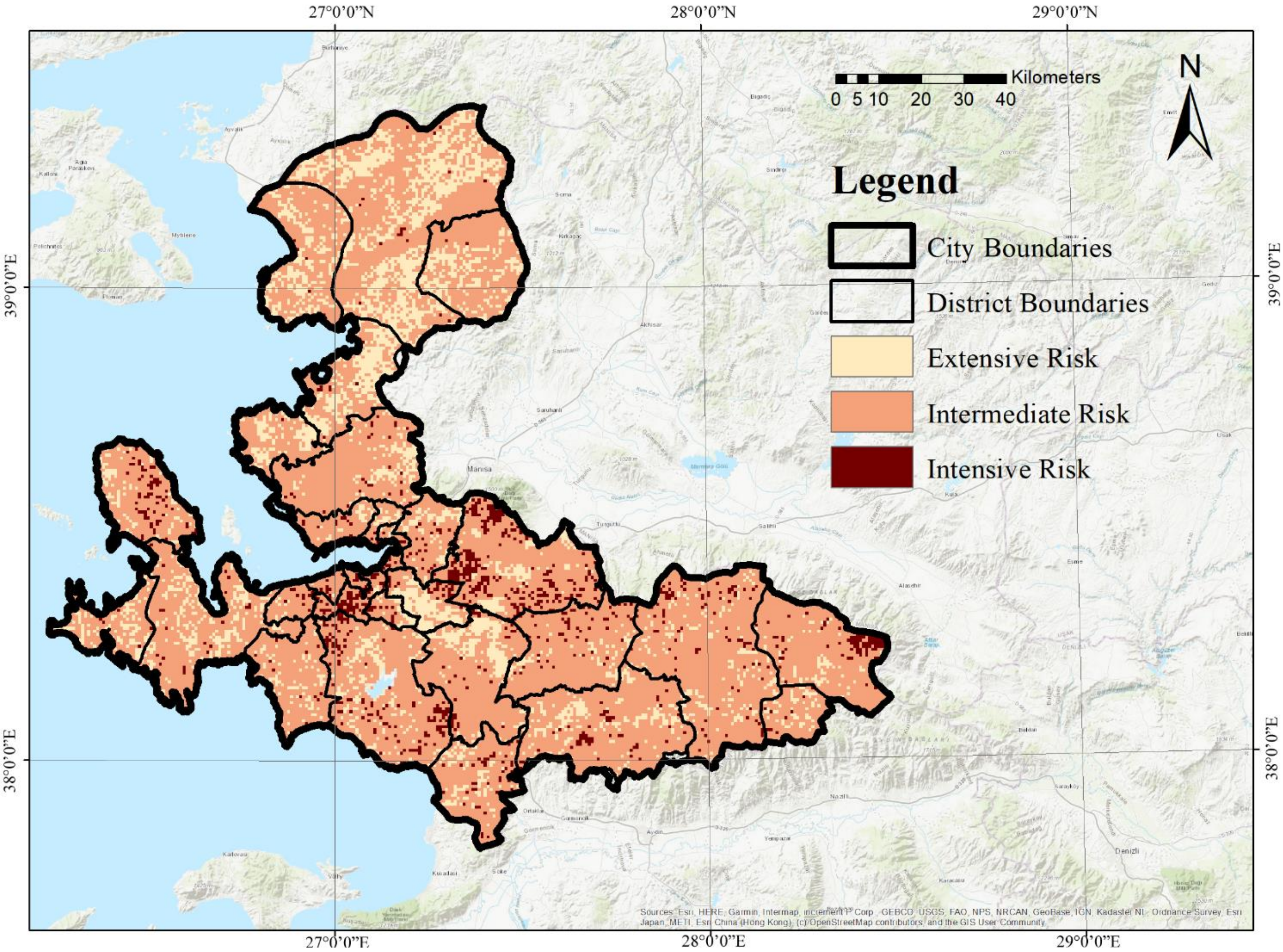

Figure 12. The disaster risk classification of Izmir city.

4. Results and Discussion

The topographic, meteorological and climatic features of the Izmir city are examined comprehensively in this study. The prominent result is that the disaster events that pose a disaster risk throughout the city are similar to the determinations related to these events prepared by the Ministry of Interior Disaster and Emergency Management Directorate. According to the data given from the Turkish Disaster Information Bank (TABB), a total of 27,049 disasters occurred throughout the country between the years 1990 – 2018 and 7616 of these disasters are landslides (28%), 1871 earthquakes (7%) and 17,562 other disasters (65%) [7]. Additionally, a total of 494 disasters occurred in Izmir city between the years 2009 – 2020 and 188 of them are fires (38%), 131 are earthquakes (26.5%), 93 are floods (19%) and 52 are other disasters (16.5%) [20].

The synthesis map is prepared as a result of spatial and non-spatial analyses and reveals the disaster risk situation of Izmir city. It is clear that it is an expected result that urban and rural areas will be affected by the disaster risks that different types of disasters may pose throughout the city. Moreover, due to the spatial analyses made using 10 basic elements related to the natural and built environment, it is determined that the districts located in the east and south parts of Izmir city (Bornova, Kemalpasa, Karabağlar, Gaziemir, Menderes, Bayındır and Karaburun districts) are relatively disadvantaged in terms of disaster risk. The districts located in the north, west and south-east parts of the province (Çeşme, Buca, Torbalı, Aliağa, Foça, Dikili, Bergama and Güzelbahçe districts) are comparatively more advantageous and the less risky. Other districts (Çiğli, Bayraklı, Karşıyaka, Menemen, Kınık, Konak, Balçova, Narlıdere, Seferihisar, Selçuk, Tire, Ödemiş, Kiraz and Beydağ districts) can be classified as medium risky. In summary, as a result of the study, it is revealed that almost all residential areas are in a more advantageous situation except for residential areas located in the east and south parts of Izmir city in terms of the disaster risk.

The findings of this study and disaster-oriented planning studies realized for Izmir city are considered comparatively. This comparison is important because the examination related to whether necessary and sufficient steps have been taken is crucial for reducing risks before possible disasters, preventing possible losses of life and property and constituting more resilient urban areas in terms of disaster risks. The report titled the Izmir Provincial Disaster Risk Reduction Plan (IRAP) is one of the documents examined in the study which has been prepared by the Provincial Disaster and Emergency Directorate of Izmir Governorship (AFAD) in the year 2021. This document comes to the fore as the main determination for the correct and effective implementations of Risk Reduction and Prevention Planning processes. Defined determinations are listed as [20]:

a. Totally 494 disasters significantly affected about 1546 houses that occurred in Izmir city between the years 2009 - 2020. In particular, the majority of the structures have been built before the year 1999 and they are not resilient for any disaster risks. In particular, the importance of urban regeneration implementations should be practiced correctly in designing the healthy, safe and resilient built environments especially with the impact of the earthquake that occurred on October 30, 2020.

b. About 6% of the population (253,802 people) is at risk of floods due to the existence of three important river basins. In this context, maps for flood risk and hazard maps have been made according to three different scenarios for 50, 100 and 500 years within the scope of the flood management plans. Various steps have been taken such as prioritizing flood-risk areas and taking the necessary measures to reduce the flood risk regarding the results obtained.

c. Totally 129 integrated disaster risk maps have been prepared within the scale of 1/25,000. These maps include a total of 109 landslide areas, 367 rockfall areas and 20 avalanche areas located throughout the city. In addition, geological – geotechnical survey reports have been prepared which are an important data in the development of plan decisions aimed at reducing disaster risks. Totally 71 survey reports are based on the disaster types throughout the planning area (landslides, rockfalls, floods, liquefaction, high groundwater, etc.). Thus, the precautions have been determined to be taken against the disaster risks and it has been provided to form the basis for land use decisions.

d. About 92% of the total 268 fires that occurred in the last ten-year period are caused by anthropogenic factors and a total area of 1137 hectares is affected. The forestation has been carried out on a total area of 6764 hectares and fire prevention facilities have been planned for the rehabilitation of fire areas within this scope.

In the report of the Izmir Provincial Disaster Risk Reduction Plan (IRAP), there exist SWOT analysis for four disaster types, 1 main goal, 27 goals and 227 action plans for disaster risk reduction have been determined. As stated in this report, the main purposes of these studies are defined to identify risks and possible effects of disasters, to take measures to reduce and/or minimize possible risks and losses of life and property caused by disasters, to identify actions and institutions / organizations responsible for these actions in order to take measures, to make the province a disaster-ready and resilient residential areas, to design healthy and safety residential areas, to make urban areas sustainable and livable by increasing the economic, social and environmental resilience of the city [20]. Therefore, responsible and supportive stakeholders have been identified on the basis of each action, the prescribed timetable for the implementation of actions has been set out and a process based on central and local governments' cooperation has been described in this plan report.

5. Conclusion

The findings obtained from the study are evaluated comparatively with the findings obtained within the scope of the IRAP report due to the studies carried out in Izmir city, it can be seen that the determinations put forward for disaster risks in particular districts showed the consistency. In addition, it has been observed that the studies have been prioritized which are carried out at the local level in terms of disaster risk management and prevention planning.

Although it is known that the crisis management stages for during and after disasters have been successfully applied in both national and local levels, the importance of risk management referring to the pre-disaster period is increasing day by day in coping with the negative effects of disasters. As a result of today's modern understanding of disaster management, risk analysis, search and rescue activities, post-incident recovery and normalization studies have become basic components of modern disaster management within the framework called the Integrated Disaster Management Cycle. It is necessary to disseminate all the studies implemented based on scientific knowledge aimed at reducing the disaster risks and using the findings obtained in a way that contributes to the designing of social disaster awareness. It will be possible to form healthier, safer and more resilient cities in the face of disasters by taking the necessary measures to reduce the risk before disasters occur.

Author contributions

Nur Sinem Partigöç: Literature Review, Spatial Analyses, Writing-Reviewing and Editing.
Ceyhun Dinçer: Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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