DETERMINATION OF FLOOD RISK AREAS AND MITIGATION STRATEGIES: A CASE STUDY OF THE MENEMEN PLAIN, İZMİR

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İsmail Gökhan GÜNSELİ

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We approve the thesis of **İsmail Gökhan GÜNSELİ**

Examining Committee Members:

Assoc. Prof. Dr. Ali Can DEMİRKESEN
Department of City and Regional Planning, İzmir Institute of Technology

Prof. Dr. Celalettin ŞİMŞEK
Torbalı Vocational High School, Dokuz Eylül University

Assoc. Prof. Dr. Koray VELİBEYOĞLU
Department of City and Regional Planning, İzmir Institute of Technology

27 June 2019

Assoc. Prof. Dr. Ali Can DEMİRKESEN
Advisor, Department of City and
Regional Planning, İzmir Institute
of Technology

Assoc. Prof. Dr. Ali Can DEMİRKESEN
Head of the Department of
City and Regional Planning

Prof. Dr. Aysun SOFUOĞLU
Dean of the Graduate School of
Engineering and Sciences

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ABSTRACT

DETERMINATION OF FLOOD RISK AREAS AND MITIGATION STRATEGIES: A CASE STUDY OF THE MENEMEN PLAIN, İZMİR

According to literature, natural disasters are increasing worldwide. Among them, flood is the most common and has the most impacts. Because of global warming and climate-patterns changing, frequency of floods has increased significantly. Also, the greatest impact among the human-oriented reasons are urbanization and industrialization. With the spread of urbanization, population in cities around the world has increased rapidly; natural areas have been destroyed, cities have been expanded. These changes have increased fragility in cities. Therefore, objective of the study was to determine flood risk areas and minimize negative impacts of floods. Accordingly, the study area; the Menemen Plain and its surroundings were found worthwhile to examine due to its topographic, climatic and hydrological structure. In this study, weighted-overlay analysis method was used in ArcGIS to determine flood risk areas employing six criteria. Therefore, six criteria that have an impact on flooding were identified as; (1) slope, (2) elevation, (3) distance from rivers, (4) distance from junction-points of river, (5) land use/cover, and (6) rainfall. The weights of criteria were assigned by land and literature investigation. According to the study, the highest risky flood locations with more population were seen as Emiralem, Kesik, Buruncuk and Çavuşköy settlements. On the other hand, medium flood risk settlements with more population were found as Seyrek, Yahşelli, Sasalı and Yenibağarası. Consequently, resilience and mitigation strategies were identified. It was stated that flood risk management should be managed in a participatory manner with a holistic approach and public-private-individual partnership with structural, non-structural measures.

Keywords Flood Risk, Flood Risk Management, Geographic Information System, Resilience Cities, Mitigation Strategies

ÖZET

TAŞKIN RİSKİ ALTINDAKİ ALANLARIN BELİRLENMESİ VE ÖNLEM STRATEJİLERİ: MENEMEN OVASI, İZMİR ÖRNEĞİ

Literatür araştırmasına göre dünya genelinde yaşanan doğal felaketler artış göstermektedir. Sel ise bu felaketler arasında en yaygın ve etkisi en fazla olanıdır. Küresel ısınma ve iklim paternlerinde yaşanan değişimler nedeniyle sel felaketlerinin sıklıklarında ciddi artışlar gözlemlenmiştir. İnsan kaynaklı nedenlerin arasında en büyük etkiye sahip olanlar kentleşme ve sanayileşme süreçleridir. Kentleşme olgusunun yayılmasıyla, dünya genelinde şehirlerdeki nüfus hızla artmış, doğal alanlar tahrip edilmiş ve kentler genişlemiştir. Bu durum kentlerdeki kırılgan alanları arttırmıştır. Bu nedenle, bu çalışmanın amacı taşkın risk alanlarını belirlemek ve taşkınların olumsuz etkilerini en aza indirgemektir. Bu doğrultuda, çalışma alanı olan Menemen Havzası ve çevresi; topografik yapısı, iklim yapısı ve hidrolojik yapısı nedeni ile incelemeye değer bulunmuştur. Taşkın riski altındaki alanların belirlenmesi için ise ArcGIS programında "weighted overlay" analizi kullanılmıştır. Bu doğrultuda sel felaketine etkisi olan altı kriter belirlenmiştir; (1) eğim, (2) yükseklik, (3) nehirlere olan mesafe, (4) nehir birleşme noktalarına olan mesafe, (5) arazi kullanımı/örtüsü ve (6) yağış değerleridir. Belirlenen kriterlerin ağırlıkları arazi incelemesi ve literatür araştırması sonucu atanmıştır. Analiz sonucuna göre; daha fazla nüfusa sahip en yüksek riskli taşkın alanları; Emiralem, Kesik, Buruncuk ve Çavuşköy yerleşmeleri olarak görülmektedir. Ayrıca daha fazla nüfusa sahip orta derecede taşkın riski taşıyan yerler ise; Seyrek, Yahşelli, Sasalı ve Yenibağarası'dır. Bu doğrultuda dayanıklılık ve azaltıcı stratejiler belirlenmiş olup taşkın risk yönetiminin yapısal ve yapısal olmayan önlemlerle, bütüncül bir anlayışla ve kamu-özel-birey birlikteliğiyle katılımcı bir şekilde yönetilmesi gerektiğine değinilmiştir.

Anahtar kelimeler Taşkın Riski, Taşkın Risk Yönetimi, Coğrafi Bilgi Sistemi, Dirençli Şehirler, Azaltıcı Önlemler

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LIST OF ABBREVIATIONS

ASTER: Advanced Space-borne Thermal Emission and Reflection Radiometer

DEM: Digital Elevation Model

DFJPR: Distance from Junction Points of Rivers

DFR: Distance from River

EMDAT: Emergency Event Database

FEMA: Flood Emergency Management Agency

FRA: Flood Risk Areas

FRI: Flood Risk Index

FRM: Flood Risk Management

GDDA: General Directorates of Disaster Affairs

GIS: Geographic Information System

HDI: Human Development Index

IFRC: The International Federation of Red Cross and Red Crescent Societies

LULC: Land Use/Cover

SHW: State Hydraulic Works

TURKSTAT: Turkish Statistical Institute

TWB: The World Bank

WDO: World Disaster Organization

WDP: World Disaster Report

WMO: World Meteorological Organization

CHAPTER 1

INTRODUCTION

Natural disasters are catastrophic events that adversely affect human life and cause economic and environmental damages as well as deaths of lives. There are many causes of natural disasters which are natural-oriented and human-oriented (Yazar, 2007). While the incidence of natural disasters and the degree of adverse impacts increase rapidly due to reasons such as urbanization, population growth, and climate change, on the other hand, the measures taken against them remain insufficient. Natural disasters in much different geography all over the world affect many countries differently according to their level of development (WDP, 2016). However, the most significant reasons to natural disasters that occur in recent years is the global climate change. Therefore, because of the severe and negative effects of the variables such as urbanization and climate change on the hazards cause it to turn to be a disaster even usually not to be the harmful magnitude (Jha et al., 2012).

According to EMDAT data, a flood is the most common natural disaster worldwide and by FEMA flood is defined as "*temporary inundation of normally dry land areas from the overflow of inland or tidal waters, or the unusual and rapid accumulation or runoff of surface waters from any source*." The frequency of the flood disaster, which causes great damages as economic and life losses, is increasing rapidly in urban areas (Karakuyu, 2002). According to EMDAT data, only in 2018, 36 million people worldwide were directly or indirectly affected by the flood disaster. In the 4973 floods (1900-2018) experienced during the year intervals held in the database, 79 billion dollar financial losses recorded. Features of the region such as climatic conditions, topographic structure, vegetation, etc. are effective on that increasing flood frequency and its effects. In addition to natural factors, human-based; deforestation, urbanization, intervention in river beds, etc. such factors are also effective (Akay, 2010). Therefore, conservation of natural areas should be the first criterion for dealing with floods.

In Turkey, the topographies are consisting of mountainous structure and have high inclination thus, accelerate the movement of the precipitation water. In particular, the transition from rainfall on bare land to the soil cannot be provided; therefore, it manifests itself as the surface flow. In other words, our country is very suitable for the flood disaster due to its climate zone and geological structure. Besides, unplanned development, interventions in natural areas and intense industrialization have been the significant accelerators in our country in this process. Especially the unplanned development in the urbanization process after 1950 caused the urban risk areas to be born, increased and uncontrolled (Benna et al., 2016). With global warming triggered by intense industrialization and consumption worldwide, countries have become more vulnerable to disasters (Karakuyu, 2002). Also, in Turkey, the most common hazard is flooding after the earthquake. The EMDAT data recorded that there were 41 major floods since 1900. In the local database, a total of 4067 floods have occurred since 1955 (Taşkesen, 2011).

Thus, present and future risks should better and more effectively manage. In this context, determining the urban flood risk areas and taking mitigation policies have been a vital process implemented throughout the world. Many organizations, particularly FEMA, have carried out flood management projects and identified mitigation strategies for flood-prone areas. Therefore, it is necessary to determine the flood-prone areas and risk assessment for these regions. Although the interventions in the flood areas started after the establishment of the State Water Works in Turkey, there are not enough practices to identify the areas at risk, to decide on the strategies and to meet the increasing disasters regarding the measures taken (Balaban, 2009).

In the study, in order to determine the flood risk areas, the causes of the floods, the consequences of floods for the measures to be taken, impact areas and examples of applications around the world were examined. For the study area, the Menemen Plain was selected which is a portion of the Gediz River Basin, one of the largest basins of Turkey. Due to the fact that area features of the Menemen Plain and its surroundings which are height, slope, river structure, land-use and wetland density that have major effects on flooding was found worthwhile to examine. Therefore, proxies were selected to determine flood risk areas according to literature research (Ouma and Tateishi, 2014; Özkan and Tarhan 2016; Gigović et al., 2017; Seejata et al., 2018). In this direction, (1) slope, (2) elevation, (3) distance from rivers, (4) distance from junction points of rivers, (5) land use/cover and (6) rainfall proxies were evaluated as multi-criteria. Weights of the proxies were assigned according to their importance of determining the flood areas. Then, The ArcGIS program and weighted overlay analysis, which are effective in flood analysis and ideal for the detection of areas at risk, were used. Because the ArcGIS program provides great convenience in making such analyzes and identifying areas at risk and it was used in many studies in different geographies to determine flood areas (Ouma and Tateishi, 2014; Özkan and Tarhan, 2016; Gigović et al., 2017; Seejata et al., 2018). Lastly, the weighted overlay method, which is one of the linear techniques in a GIS environment, was used. By overlaying the individual layers, this approach evaluates the overall criteria. As a result of the analysis, a map of areas under risk of flood was created.

Consequently, the determination of the areas under risk of flood and risk rating was performed by weighted overlay analysis in the ArcGIS software, and a resultant map classified according to the risk index is determined. Thus, in accordance with this risk map, the plan decisions of the city for the expanding urban texture were updated and risks eliminated by the mitigations practices for the study area

The problems and the structure of the thesis have described in the following titles.

1.1 Problem Definition

Application deficiencies on the determination of flood areas and taking measures to mitigate adverse impacts of the flood disasters, flood management plans, planning decisions without any flood risk analysis and non-implementation of integrated precautionary policies are issues that need to be evaluated. Therefore, the purpose of this study is to reduce negative effects of disasters on the earth, the flood disaster which is one of the most common disasters. Also, the study tries to focus on evaluating the problems below for the study area, the Menemen plain and its surroundings, which is a sub-basin of the western Gediz River Basin:

- What causes the flood disasters and what kind of criteria should be taken into consideration to determine the flood risk areas for settlements and agricultural alluvial plains?
- What weights of the criteria and which analysis method can be relatively appropriate to determine flood risk areas?
- What level (degree) of the flood risk as the flood risk index has the study area got?
- What measures can be taken in to prevent or mitigate flood risks in the study area?
- What measures can be taken for flood risk in Urban Planning in the study area?

1.2 Structure of the Thesis

The thesis consists of six chapters. The first chapter is an introduction which includes general information about thesis and why this topic is important. It also contains research questions about the study. The rest of the thesis organized as follows;

The second chapter explains the topic of disaster and types of disasters and risk terminology. Also, gives information about world-wide databases that used as a source in the thesis. In addition to that emphasize the effects of the disaster in worldwide and in Turkey with much statistical data. Moreover, this chapter includes disaster management strategies which are classified before and after disasters. Lastly, mention about risk management and vulnerability topic which is the most significant point to consider while analyzing and taking action for flood risk.

The third chapter briefly explains the definition of flood and flood types. Then it gives information about the causes of flood and impacts of the flood. Investigate the urbanization as a cause of the flood and shows the effect of urbanization on nature and natural disasters. Moreover, the third chapter consists of the topic of flood disaster with statistical data and many worldwide examples to emphases why the topic is important. After that mitigation and resilience strategies are examined within the scope of the thesis, also management examples with events are mentioned. Last part of this chapter includes recent previous studies about the thesis topic.

The fourth chapter gives general information about the study area and examined the study area information with relevant to the topic, such as environmental plan investigation. Also, it explains the sources of the data and process of the analysis. It includes the examination of six criteria with the analysis method, thematic maps, and quantitative data.

The fifth chapter explains the final analysis of six criteria and shows the flood risk map of the study area. This chapter contains an examination of the final map, and mitigation strategies which can be applied to study are.

The final chapter briefly summarizes the study and emphasizes its contributions for further studies.

CHAPTER 2

DISASTER AND RISK

A disaster is a catastrophic event that occurs suddenly and causes loss of life and property. According to the International Federation of Red Cross and Red Crescent Societies (IFRC), it is defined as "*Disaster is sudden, calamitous event that seriously delay the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources.*"(IFRC.org).As it is indicated in the definition, an incident becomes a disaster when the society cannot handle the situation, and consequently, it affects daily life in a negative way (Lindell et al., 2006). As a result, we should consider the disaster as an outcome not the reason and investigate the topic around preventing this outcome. The common results of disasters are; loss of life, goods, agricultural areas, settlements, historical places, and infrastructure. Even if a disaster affects society sudden, its result may be indirect or long-term damages.

These economic, social and environmental losses determine the disaster magnitude. Among these results of disasters, human lost is the most important one that is why they are generally measured according to mortality rate (Ergünay, 2002). The main factors that affect the size of disaster are; distance of the settlements, lack of education, lack of knowledge, rapid population and which comes with it unplanned structural development (unauthorized buildings; slums etc.), poverty and the most importantly destruction of forest and natural environments (Gökçe et al., 2008). It was indicated that the disasters influence the developing countries more than developed countries since they have limited or no facilities to cope with the situation. Therefore, 95% more loss of life are seen in developing countries compared to developed countries (TWB, 2006).

2.1 Disaster Classifications

Disasters are categorized in two ways as taking place and type. Sudden and creeping disasters, which happen rapid and slow, respectively, are the sort of the occurrence ratio. Although the occurrence of sudden disasters such as earthquakes, floods, and landslides could be foreseeable, however, their certain time and day cannot be known. On the other hand, precautionary warnings can be easily taken for creeping disasters like drought, deforestation, and pollution (Uzunçıbuk, 2009).

Besides, disasters can be subdivided into natural and technological (Hoyois et al., 2006). Technological ones generally happen as a result of people's mistakes. Construction collapses, vehicle and industrial accidents are examples of this type of disasters (Gökçe et al., 2008).

2.2 Worldwide Statistics

Natural disasters are problems that occur for thousands of years and are defined as disasters to their effects. There are several databases related to their causes, effects, and types all over the world. These databases specify the disasters according to specific criterions which can be exemplified as follows (Tschoegl et al., 2006) (Figure 2.1).

Disasters that

- cause 10 or more people died,
- affect 100 or more people,
- their aid status is explained,
- are desired for international help

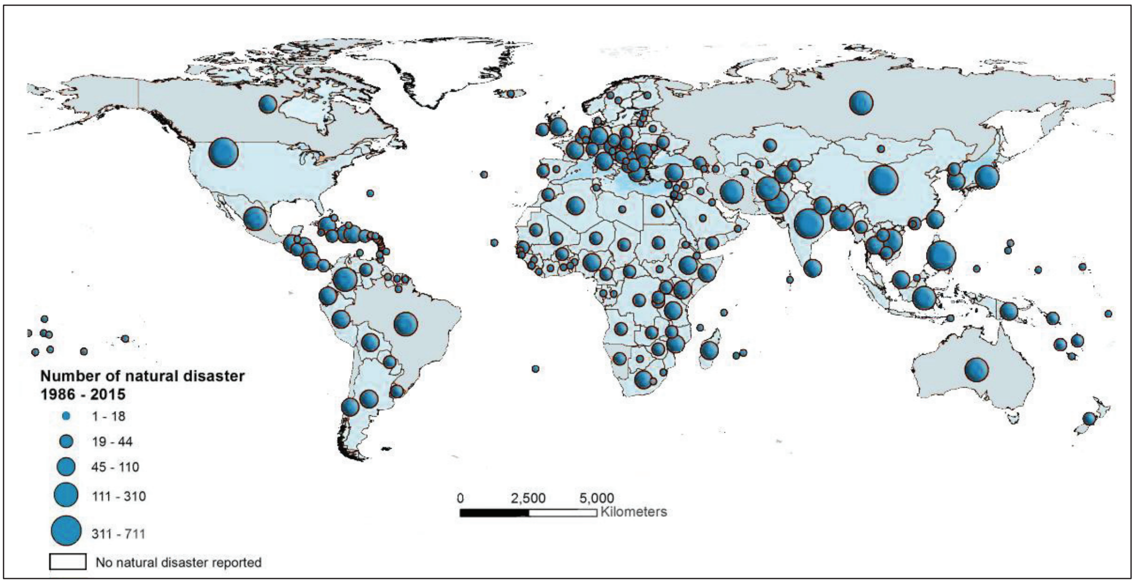
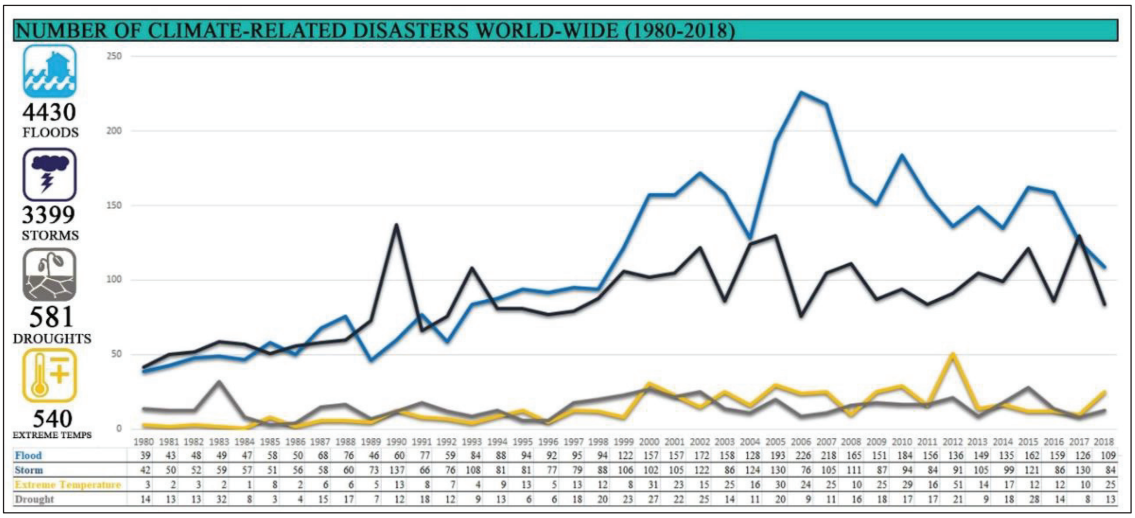


Figure 2.1. Number of disaster between 1986 and 2015
(Source: EM-DAT, 2019)

Mapping of places in the worldwide that are affected and not affected by natural disasters is done according to database EM-DAT. The visualization that consists of the year between 1986 and 2015 indicates that several natural disasters occur in the world.

When the natural disaster distributions are examined by years, it is seen that there is a significant increase in the number of natural disasters over the past 50 years. The biggest reason for this increase is climate change and its effects on world-wide. In this perspective, climate-related disaster around the world between the years 1980-2019 according to their occurrence is like below (Reynard et al., 2001) (Figure 2.2).



	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Flood	39	43	48	49	47	58	50	68	76	46	60	77	59	84	88	94	92	95	94
Storm	42	50	52	59	57	51	56	58	60	73	137	66	76	108	81	81	77	79	88
Extreme Temperature	3	2	3	2	1	8	2	6	6	5	13	8	7	4	9	13	5	13	12
Drought	14	13	13	32	8	3	4	15	17	7	12	18	12	9	13	6	6	18	20

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Flood	122	157	157	172	158	128	193	226	218	165	151	184	156	136	149	135	162	159	126	109
Storm	106	102	105	122	86	124	130	76	105	111	87	94	84	91	105	99	121	86	130	84
Extreme Temperature	8	31	23	15	25	16	30	24	25	10	25	29	16	51	14	17	12	12	10	25
Drought	23	27	22	25	14	11	20	9	11	16	18	17	17	21	9	18	28	14	8	13

Figure 2.2. Number of climate-related disasters around the World 1980-2018

(Source: unisdr.org, EM-DAT, 2019)

When the meteorological disasters are analyzed in the database of the United Nations, it is observed that 8950 disasters occurred in the year between 1980 and 2018 and 4430 of them were determined as a flood. Even though some decreases have been observed since 1980, it increases in general.

In Turkey, first studies related to disasters began in the 1940s, and they form the natural disaster database in specific standards until today. This database consists of technological and natural disasters that are matching the criteria. They can be categorized as follows:

- At least 10 deaths,
- At least 50 injured,
- At least 100 people who are affected by the disaster,
- Negative effect on the lives,

- Demand for immediate aid (Gökçe et al., 2008).

If the disaster has any of these criteria, it is involved in the database.

Moreover, Turkey is a country that experiences frequent natural disasters of meteorological origin too. Among these disasters, the flood is one of the types that happens frequently with a proportion of 30%. Numbers of meteorological disasters only cause loss of life and property are shown in the table below. Disasters apart from these are not included in the table and considered as just a meteorological phenomenon (Ceylan, 2003).

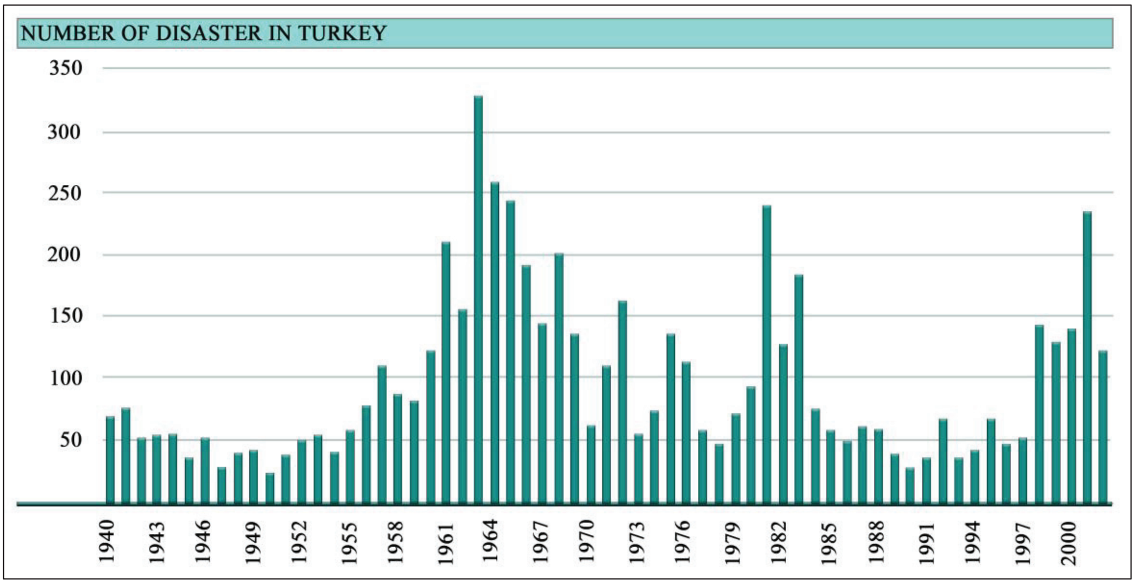


Figure 2.3. Number of disasters in Turkey
(Source: Ceylan, 2003)

The disaster table for Turkey demonstrates that after 1950 the number of the event increased significantly, it is because of urbanization and industrialization period of Turkey. This effect of urbanization will be examined in the next chapter. In general, between 1940 and 2000s, it can be clearly seen that there is an increasing trend even though some fluctuations.

Turkey has faced a lot of disasters throughout its history due to its physical structure and location which are the reason for being on the fault line and having big rivers. These hazards turned into disaster many times because of the lack of preparations, population growth, unplanned urbanization and lack of education and they damaged people and the environment. As well as in the world, natural disasters have constituted big problems for Turkey with respect to people and the economy. According to examine data, approximately 120,000 people have lost their lives due to natural disasters since the establishment of the republic. In terms of economics, almost one million buildings have been damaged, thousands of vehicles, animals, and materials have been lost, and thousands of working places have been closed (Akdur, 2000).

2.3 Disaster Risk

Main factors that affect the magnitude of natural disasters can be summarized as follows:

- The distance of the disaster from the settlements,
- The physical magnitude of the disaster,
- Poverty and underdevelopment,
- Rapid population growth,
- Rapid and uncontrolled housing and industrialization in risk areas,
- Destruction and misuse of the forest and the environment,
- Lack of education and knowledge,
- Protective and preventive actions (Kadıoğlu and Özdamar, 2008).

Considering the urban areas, they have high risk due to structural features such as the concentration of the population, non-agricultural economic activities, demographic and socio-cultural activities like specialization in business lines. Societies are gradually considered to be risk factors because of these features and the modernization process, and this situation is explained by the concept of "risk society." (Beck, 1992) The increase in the world population and the increasing number of this population to settle in cities make the cities even more risky against disasters (Genç, 2007).

In this context, there are many different models developed about the factors that make people vulnerable in the face of natural disasters. These models aimed at identifying the risk more clearly (Nathan, 2005). Some of these models argue that the vulnerability is in interaction, and it occurs in areas, where the disaster is likely to happen, as a result of a combination of shortcomings such as population density, destruction of natural life, climate change, lack of legal and institutional arrangements occur as a result of a combination (Genç, 2007).

One of the most well-known models developed within this framework is the Impact-Response Model. This Blaike's model combines the social factors that create disaster and the development of its impacts on people. This model is considered as advantageous since it clearly distinguishes the concepts of risk and vulnerability and makes the social science analysis possible (Nathan, 2005). According to the model that deals with the natural disaster risks from the viewpoint of vulnerability, the structure and resources that are limited in the social structure constitute a dynamic element of oppression, and the population confront with the unsafe conditions as a result of rapid population growth, rapid urbanization, war, decreasing social life standards and environmental degradation. Consequently, a risky, and an unprepared social structure occur in the face of disasters (Özerdem and Barakat, 2000). According to the underlying idea of the model, disasters happen as a consequence of the interaction of two forces; on the one hand, the factors that lead to damageability and on the other hand, nature event itself (Wisner et al., 2004).

As mentioned before, natural disasters are accepted as disasters based on their effects. Unconscious risk and disaster management policies, unprepared and unplanned housing not only increase the affected area and the level of the disasters but also induce a hazardous, which might have a low-level impact on the environment, to become a disaster. Therefore, projects that aim to decrease the effects of disasters should be carried out. It is possible to perform these projects as before and after the disaster, so that handle the disasters in an integrative way (Ergünay, 2002).

2.4 Disaster Management

Disaster management is an integrative approach that consists of some manners such as well detection of risks that may cause the hazard to become a disaster, removal of these risks by following reasonable way and minimization of the damages. (Ergünay, 2002). Precautions like institutional structuring, infrastructure investments, adoption of sustainable urbanization and legislative regulations can be accomplished by public support and participation. For this reason, education and awareness are the primary subjects of disaster preparation practices and they will be beneficial to all works related to disaster mitigation (Güler, 2008).

Disaster should be considered as a consequence. Therefore, it is the losses and the negative outcome that is caused by an event or a hazard. If it is formulated, it should be considered as follows: (Kaplan and Garrick, 1981; Mileti, 1999)

Risk = Hazard * Vulnerability

In other words, when risk evaluation is carried out in disaster management, vulnerability is firstly investigated. That is why determining areas that have high vulnerability and increase the protective and preventive actions are essential to mitigate and remove the damage completely.

Disaster management concept can be categorized into two parts which are before and after a disaster (Ergünay, 2002).

Before the disaster:

- To take technical precautions like legal regulations and administrative acts before the disaster happens,
- To ensure that the first aid and rehabilitation works get done in a fast and efficient way,
- To include the disaster precaution actions into a five-year development plan,
- To perform awareness raising works about disaster information culture and creating the perception in the society.

After the disaster:

- To rescue the maximum number of people and to supply health care,
- To protect people and their properties from direct or indirect hazards that can be caused by the disaster,
- To normalize life as soon as possible and to provide the basic needs of society,
- To ensure the economic and social losses, which can occur after a disaster, are minimum,
- To constitute a new, safe and developed environment for communities who are affected by the disaster.

In the planning of damage reduction, alternative actions, which are involved in the national flood insurance program of FEMA in 2000, are written below:

- To determine the areas that are under risk and to do the urban planning taking into account these areas,
- Reinforcement of the buildings with laws, regulations and engineering works,
- To prevent natural habitat destruction, to provide their sustainability and to allocate resources to goal-directed expropriation,
- To decrease the effects of natural hazardous by structured solutions and to control them,
- To limit the investments in the areas that are specified as risky,
- To raise awareness of society (FEMA, 2000).

Even though disasters occur everywhere in the world, they pose more risk in the dense and unplanned urban areas. Therefore, it is crucial to set a goal in line with the city planning principles and to adopt the sustainable planning approach in order to mitigate the risks which are caused by natural hazardous in the urban areas. Therefore, some subjects should be taken into account in the sustainable planning approach:

- To evaluate the housing in the regional ecosystem,
- To regard the conservation-utilization balance for environmental/natural resources,
- To use the settlement areas efficiently by minimizing the urban sprawl,
- To reduce the risks with suitable land use planning in urban areas,
- To encourage sustainable transportation models,
- To supply the economic welfare and buoyancy in settlements,
- To strengthen equality and social integration in urban areas,
- To develop sustainable financial and legal means,
- To provide participant management and corporate organization (Tezer and Türkoğlu, 2008).

2.4.1 Disaster Management in Turkey

In Turkey, about floods and earthquakes, firstly the law no. 4373 *"Protection from Overflow and Flood Law"* and the law no. 4623 *"Precautions Before and After Earthquakes Law"* were introduced in 1943 and 1944, respectively (Gökçe et al, 2008).

When the duration after 2000 is evaluated, the Disaster and Emergency Management Presidency was constituted in 2009 in order to manage the disaster and emergency in our country. With becoming operational of this presidency, Disaster and Emergency High Council, Disaster and Emergency Coordination Council and Earthquake Consultative Committee were established (Taşkesen, 2011).

2.4.2 Disaster Management in Worldwide

In United States of America FEMA is an independent agency which is in charge of disaster and disaster management. It was established in 1979 to protect the country from the hazard in every emergency. Also, it aimed to minimize the loss of life and property and to provide the risk-based emergency management planning that contains intervention and improvement actions. FEMA helps to county and local government when the damages, which are caused by risks or disasters, exceed their capacities. Also, FEMA coordinates the federal emergency management works and planning to maintain the management in case the national security gets into danger. Moreover, to reduce the flood risk and to ensure, to decrease the disaster damage, and to help the community for preparing to disaster are the other work among their missions (Gündüz, 2008).

In Japan, it was decided to perform the disaster management system after Ise-Wan Typhoon that took place in 1959 and then two years later; it began with The Disaster Countermeasures Basic Act (TCB, 1997).

2.4 Terms of Risk and Risk Management

The term “risk” is widely used in most of the areas. However, it was originally utilized in the business sector and defined as the possibility of getting harm or endamaging. Afterward, it was also used in other fields such as economy, finance, politics, military, medical, law and mathematics (Merz et al., 2007).

In other words, the risk term is a probability of occurrence of an event that will cause harm or loss. Even if the possibleness and negative effects of this situation are known, its time could not be estimated accurately (Koyuncu, 2010). Also, natural disasters are the probability of natural catastrophe transformation to disaster based on three fundamental factors which are magnitude, vulnerability, and exposure (World Meteorological Organization, 2008).

2.4.1 Risk Management

To determine the disaster risk, firstly hazards that could result in disaster should be specified. Besides, the magnitude and frequency of these hazards, factors like population, infrastructure, buildings, and environment, which could be affected by these hazards, should be identified (Ergünay et al., 2008).

Process of risk management includes preparation of disaster scenarios, determination of practice priority, and preparation of general policies, strategic and application plans in order to reduce risks. All necessary precautions that control or decrease risk are called risk management (Efeoğlu et al., 2010).

The disaster management steps; related to damage reduction, preparedness, prediction, and early warning form the risk management component that involves the pre-disaster conservation works. In the stage of harm reduction, precautions are taken to decrease the losses that could be the results of the disaster. This stage has great importance since it is known that the complete removal of disaster is not possible. Operations that should be done in this step can be organized as follows (Ergünay, 2002):

- To update the disaster regulations,
- To evaluate and mapping the risks based on the residential areas,
- To specify and mapping the groups in residential districts that are under risk,
- To reinforce the important buildings like hospital, facilities, and infrastructure which are under risk,
- To generate disaster scenarios, to evaluate the solutions and to set up the early warning systems,
- To give education and to create awareness about disaster damage reduction,
- To prepare the short/medium/long term harm mitigation plans.

Also, several activities such as developing and applying the preventive and harm-reducing engineering measures can be considered as the main activity in the damage decrease step (Taşkesen, 2011).

2.5 Vulnerability

Vulnerability is the most essential component in determining whether exposure to a hazard poses a risk, which could result in disaster, or not (World Meteorological Organization, 2008). Combination of components, which are included in the vulnerability concept, identify the risk level of a person's life, cost of living, property, and other circumstances with the separate and definable event (or series or 'consecutive' events) in nature and community.

The concept of vulnerability should be considered as a value. In this calculation, some top terms such as coping, estimating, reacting or recovering should be evaluated. To think in detail, some regions or people are more vulnerable to natural disasters. This contains several variables, and some of them are occupation, demographic structure, location, and wealth.

Naturally, urban improvement generates more significant risks. However, these risks can be prevented by people who are high-income earners and can be overcome their harms by low-income groups. Socio-spatial differentiation can be seen related to exposure to the danger of the residential areas. In urban areas, there is an increase in the potentially harmful substructure and materials such as bridges, municipal and industrial wastes, chemicals and power plants and they cause an increment in the urban population's physical vulnerability. Secondary hazard and detriment risks increase because of the substructures, which affect health in a negative way, such as sewage sludge purification facilities, dump sites, and hazardous industries. Therefore, socio-economic considerations should be taken into account within the scope of the residential district (World Meteorological Organization, 2008).

Schanze (2006), indicated that the flood vulnerability could be classified in three ways, which are economic, social and cultural, and ecological vulnerability, with regard to sustainability. Economic vulnerability specifies "direct and indirect financial losses by damage to estates, main material, and goods, decreased productivity and aid works" while social and cultural vulnerability indicates "the loss of life, health effects (injuries), loss of aliveness, stress, social influence, loss of personal belongings, and loss of cultural inheritance". Lastly, ecological vulnerability tackles the water, soil and ecologic pollutions originating from human activity (Schanze, 2006).

CHAPTER 3

URBAN FLOOD RISK AND FLOOD RISK MANAGEMENT

Floods that can shortly be defined as "*a temporary covering of land by water outside its normal confines*" by Munich Re (1997) also "*temporary inundation of normally dry land areas from the overflow of inland or tidal waters, or from the unusual and rapid accumulation or runoff of surface waters from any source*" by FEMA (1986).

Fundamentally, floods are an event tied to the use of space, climate, vegetation, topography, and human intervention. So it is possible to say that floods occur not just by natural causes but via human intervention as well. For example, destruction of natural areas, the rapid growth of agricultural areas, interventions to water beds and irregular urbanization are some of the causes that make floods to evolve into natural disasters (Turan, 2013).

3.1 Flood Types

There are many examples that classified flood hazards. For example, Kadıoğlu (2008) divided into three in terms of generation time of the flood hazards and these are; slow-onset floods, rapid-onset floods, and flash floods. In addition to that location is another critical situation for flood hazards. For the location of the flood, there are five classes which are the river, mountain, urban, coastal and dam floods (Kadıoğlu, 2008).

However, several databases EM-DAT first of all- study floods under three main captions. These are riverine floods, coastal floods and flash floods:

Riverine floods occur when the river stream exceeds the existing current volume. It happens when the river level raises in a couple of weeks and creates a flood, especially with the help of sloped areas.

Coastal Floods are the type of floods that occur when factors like the erosion of the coastal line, urban areas built on river beds or areas where rivers pour into the bodies of water cause the sea line rise in times of rain or storm thus flooding the coastal line.

Nowadays, one of the main reasons for these types of floods are the consequences of global warming.

Flash Floods occurs in times of extreme downpour, when currents originated from high sloped areas cannot be discharged via drainage canals thus affecting habitats and urban areas. In contradistinction to riverine floods, flash floods develop rapidly (WMO, 2008).

3.2 Understanding Cause of Urban Flood and Urban Flood Risk

The term flood, a phenomenon causing it and effects of floods must be examined thoroughly before evaluating flood risks and creating analyses determining potential flood zones. It is possible to sort causes of flood into two titles as natural factors and human-caused factors. Natural and human-caused factors that create floods or affect them can be sorted as so:

Natural factors:

- Extreme and severe downfalls
- A sudden melt of snow
- Earthquakes, landslides, and erosions
- Climate change
- Geologic structure and characteristics of the land
- Vegetation
- Hydrology

Human-caused factors:

- Wrong use of land
- Destruction of natural areas
- Interventions on river beds
- Rapid urbanization and population growth (Yazar, 2007)

In addition, many natural disasters caused by human-oriented natural changes are growing in numbers. Farming, deforestation, and urbanization increase the speed of rain flow. Thus even storms that cannot create a flood can so. These changes are illustrated in figure 3.1.

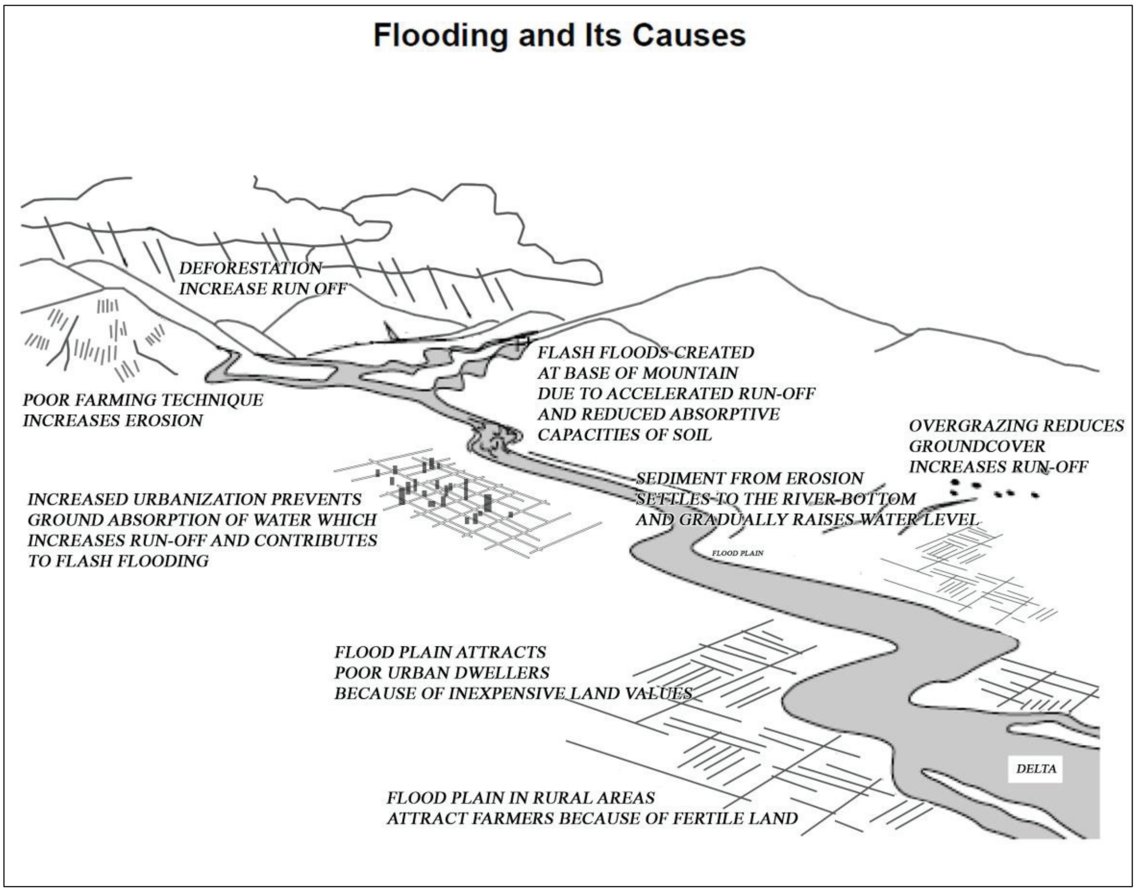


Figure 3.1. Causes of flood disasters (human-oriented)

(Source: Jha et al., 2012)

Also, scientist asserts that the majority of floods are caused by changes in the climate and the use of land (Reynard et al., 2001). For example, Harden (1993), stated that surface current developments differ due to the changes in the use of land. Molina et al., (2007) studied surface current development on different use of land under artificial rain and noted that changes in the use of land affect the surface current development.

Thus the nature of the land is vital in the formation of flood disaster. In this context, the most fragile and sensitive lands can be summed as:

- Active flood areas and lower bits of river beds
- Local areas exposed to sudden floods (high sloped valley gaps)
- Flattened shore areas
- Alluvium fields (Smith, 1992).

To link urban planning and natural disasters it is essential to explain the effects of urbanization on the climate and therefore natural disaster. The effects of rapid urbanization and growth of population which followed the industrialization after 1950s on natural disasters will be examined under the title “Urbanization”.

3.3 Urbanization

It is possible to define the term urbanization as a transition of population from rural areas to urban ones. It can also be defined as an increase in the rate of the population living in urban areas and the process of society adapting to it. The term urbanization came to exist rapidly in developing countries especially after 1950s. This trend of migration, which continues rapidly from rural areas to urban ones brought along the housing problem. The existing urban fabric, which cannot meet the increasing population as social and physical infrastructure, is left to the lap of distorted urbanization and illegal structures (Figure 3.2) (Sağlam, 2006).

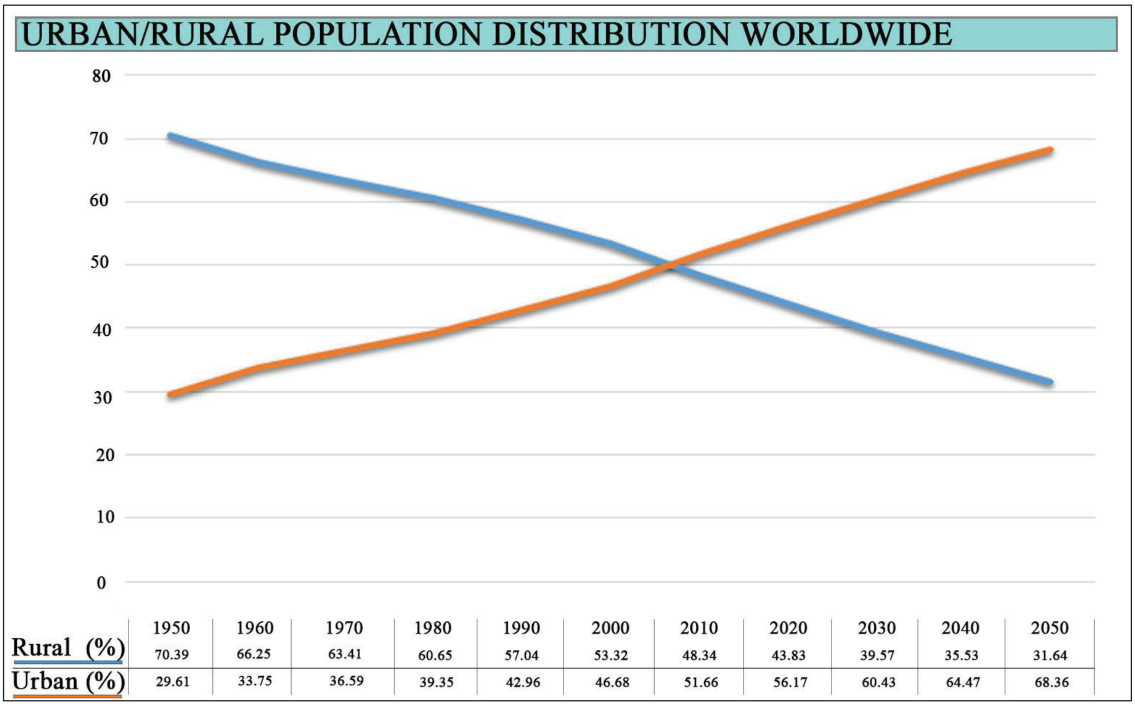


Figure 3.2. Population projection of urban and rural areas
(Source: Urbanization, 2018)

In the same way, the people who came to the cities in the struggle for urbanization had to construct illegal structures in the regions where natural risks were intense or not suitable for building due to the same reasons. The urbanization processes in the developing countries have progressed parallel to each other. According to the data of the United Nations, for the first time in history, the urban population has risen above the rural population by 2008. It is estimated that in 2030 the city population will reach 60%, and 70% in the coming years (Jha et al., 2012).

This increase in the urban area and the fact that developing countries cannot solve the housing problem forces the poor to informal constructions. For this reason, urban risk has increased with the population in the countries that could not respond appropriately to the urbanization process and could not meet their returns. Distorted urbanization, inadequate infrastructure, insufficient legal regulations, etc. are some of the many factors have caused to increase the vulnerability of the city (Bicknell et al., 2009).

Considering the urbanization phenomenon that triggered climate changes due to land use, vegetation, and natural areas, and increasing flood events in urban areas, it is possible to say that urban flood is a serious and growing development problem. Population growth, urbanization trend and climate change and the reasons for the flooding are shifting from natural causes to human causes, and their effects are increasing rapidly. Although the impact values are different, the damage caused by flooding covers all developed and developing countries. It is necessary for people to re-analyze the reasons that shift from natural to human-based for flooding and to set policies for reducing future risks (Jha et al., 2012).

Urban areas are becoming increasingly more risky and costly. Especially in developing countries, short-term exposure to flooding for urban settlements and factors affecting fragility is increasing rapidly. If we consider the short definition of urbanization as the migration of people from rural areas to urban areas, this means that more people are put under the risk of flooding in urban areas. Rapidly growing informal structures (slums) are particularly vulnerable areas and have no resistance. These areas, which generally do not have sufficient service and infrastructure services, are the areas at the highest risk. In other words, considering the slums and the fragile areas in which they are located in line with the housing problem in urban areas, disaster risks bring the disadvantaged groups under the influence or risk of being more easily affected. Although the flood risk in urban areas is often mentioned, the risk of flooding affects all habitats and should not be classified as urban or rural. However, there are significant differences between the floods in urban areas and the impacts and functionality of the floods in rural areas. While floods in rural areas affect more extensive areas and poorer people, flood effects in urban areas are more costly and more challenging to cope with. Because urban sprawl changes the natural environment, land uses and land cover, flood risk is higher in city centers and the rapid growth of cities, especially those located along rivers and coasts, increases the risk of people and assets being exposed to flooding. Therefore, the damage is much more intense and costly (Jha et al., 2012).

In this context, the most affected by the flood disaster; It is possible to list those who live in small towns with a lack of infrastructure, especially at the level of urban poverty, in the vulnerable areas or in those who live in fragile structures or in the disadvantaged groups remote to social services that are difficult to cope with (World Bank 2010).

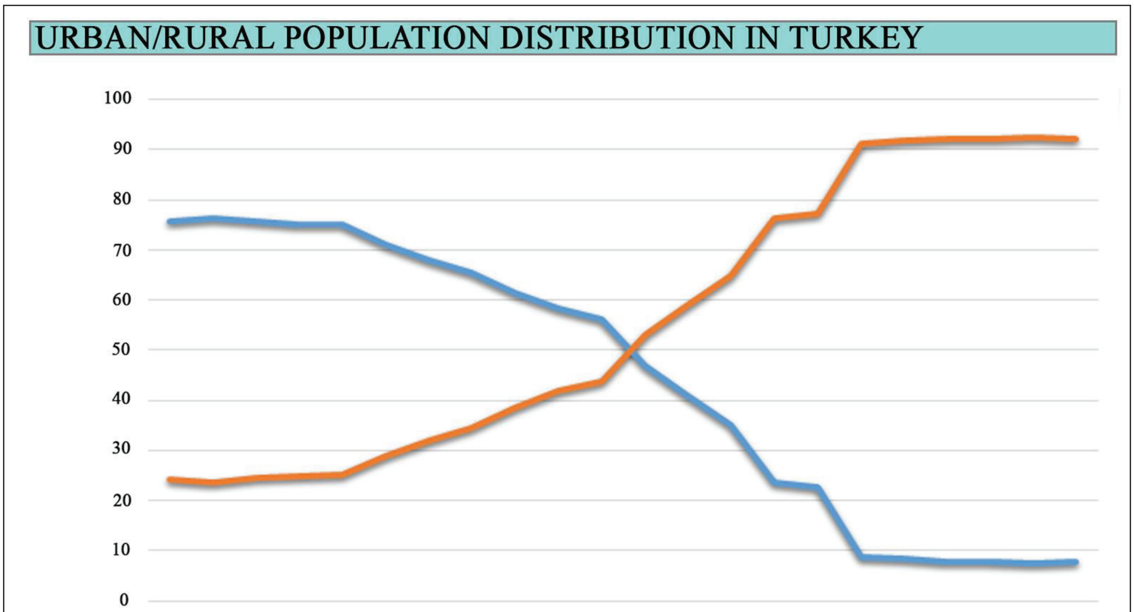
Consequently, in order to address the risks faced by cities and urban areas in developing and underdeveloped countries, a consistent, locally specific and integrated response to this environmental hazard and risk is needed.

3.3.1 Brief History of Urbanization in Turkey

In Turkey, while describing the process of urbanization, it is possible to talk about two periods before and after 1950. Between 1927 and 1950, the rural population was dominating the country, but by 1950 there was a very slow movement towards the city. (Uzunçıbuk, 2009) After 1950, a rapidly increasing urbanization process began. Especially in industrial and coastal cities, it is observed that migration has widened nowadays and that not only big cities or industrial centers but also many places have migrated with different purposes. In 1927, Turkey's population was recorded as 13.6 million. In this period, the urban population was only 2.2 million. By 1965, the total population increased to 31.4 million while the urban population reached 9.4 million (Figure 3.3) (Geray, 1969).

In the 1980s, the urban population remained at a rate of 43.9% of the rural population for the last time. As of 1985, the rate of the population living in urban areas increased to 53%. It is seen that the increase continued in the 2000s and these rates have reached 60% in the 2000s (Keleş, 1995). Nowadays, almost 92% of the population live in urban areas where the rural population is only 7.7%.

As in the other countries around the world, Turkey also experienced rapid urbanization process, and with it; population growth, uncontrolled illegal buildings, climatic change and therefore, as a result of these, natural disasters (Gigović et al., 2017).



	1927	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	2000	2010	2012	2013	2014	2015	2016	2017	2018
Rural (%)	75.8	76.5	76.6	75.1	75	71.2	68.1	65.6	61.5	58.2	56.1	47	41	35.1	23.7	22.7	8.7	8.2	7.9	7.7	7.5	7.7
Urban (%)	24.2	23.5	24.4	24.9	25	28.8	31.9	34.4	38.5	41.8	43.9	53	59	64.9	76.3	77.3	91.3	91.8	92.1	92.3	92.5	92.3

Figure 3.3. Population distribution between urban and rural areas 1927-2018 (Source: TURKSTAT, 2018)

Consequently, urbanization period affected countries' natural areas and resources, settlements, industries, and population. In this perspective, the link between urbanization and natural disasters are examined in the next title.

3.3.2 Effects of Urbanization on Natural Disasters

As mentioned before, one of the areas at risk of natural disasters caused by urbanization is slum areas. In Turkey, many legal regulations such as legalization, zoning amnesty, and reconstruction peace have been made. Due to the housing problem, in the beginning, this situation caused the slums to be traded over time. Therefore, these regions can be considered as areas with the highest urban risk.

Urbanization has also an impact on the natural environment. In order to meet the increasing population, new residential areas, prepared within this framework or later drawn out plans and infrastructure areas were constructed without foreseeing the future and the natural environment was plundered. In particular, the destruction of forest areas due to industrial areas, pollution of water resources and air pollution are among the effects of urbanization. In short, rapid urbanization has made urban areas vulnerable.

The study by Hollis in the mid-1970s shows that the frequency of small floods may increase by ten times with rapid urbanization. The increase in urban areas in land use causes an increase in impermeable areas. In other words, as the urbanization rate increases, the penetration of rainwater into the underground is decreasing (Hollis, 1975). This situation affects the flow rates of the streams passing through the cities. With the addition of rainwater in urbanized areas, the flow increases by 2.5 times, and the flow rate increases by eight times with sewage flows (Karakuyu, 2002).

In 1992, Smith listed the reasons for the magnitude of flood risk and the frequency of occurrence in a similar way into four divisions. These are briefly; decrease in the permeability of liquid in urban areas, increase in the flow rate due to insufficient infrastructure, increase in the amount of liquid waste due to urban reinforcement and population density. Shortly, the negative effect of urbanization is under two titles which are; increase accumulation and decrease absorption. As a result, urbanization has shown a significant impact on both global climate change and the frequency of natural disasters (Gigović et al., 2017).

Considering that rapid urbanization and industrialization triggered global warming, the impact of global warming on floods should not be overlooked;

- Increase in sea water levels
- Increase of flood and flash flood rates in the river due to a rain pattern change
- The loss of groundwater as a result of the decrease in permeability rates, and therefore the occurrence of ground sediments, indirectly increase the sea levels.
- Cause extreme rains and storm due to the climatic pattern change

These are just some of the effects of global warming (Jha et al., 2012).

3.4 Flood Event and Loses Worldwide

In many countries of the world, flood events occur regardless of their climate zone or conditions. According to EM-DAT data, a total of 724 erosions, 1374 earthquakes and 4973 times of floods occurred between 1900 and 2018. In the light of this data, a flood is the most common disaster in the world. Besides, the economic losses caused by natural disasters are considered, 40% of the economic losses are caused by floods and more than half of the deaths are directly or indirectly related to the flood (Table 3.1).

Table 3.1. Total statistics of disasters between 1900 and 2018

(Source: EM-DAT, 2019)

Disaster Type	Occurrence	Total Deaths	Affected	Total Affected
Drought	728	11,731,294	2,691,154,607	2,691,174,607
Earthquake	1,374	2,582,077	170,031,766	195,665,160
Flood	4,973	6,980,190	3,715,254,795	3,809,317,619
Landslide	724	65,777	10,004,300	14,276,924

EMDAT data records; when the frequency of flood disaster is examined according to the years between 1900 and 2018 in the world (Figure 3.4).

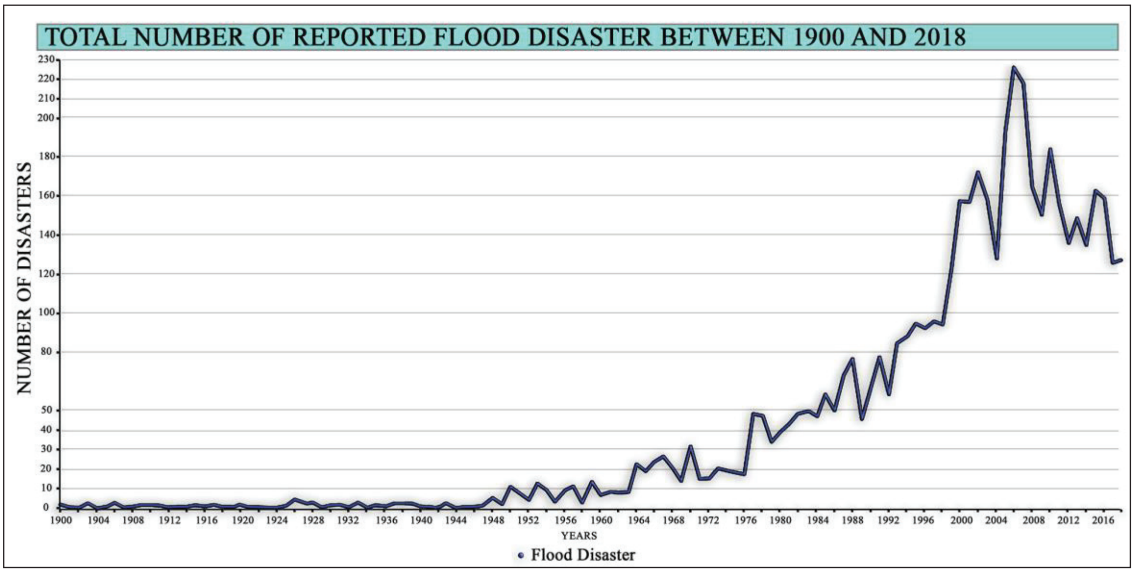


Figure 3.4. Number of reported flood disaster between 1900 and 2018

(Source: EM-DAT, 2019)

The examination of the flood disaster by years illustrates that significant changing in the number of flood disaster can be easily seen it is parallel to the urbanization period. As mentioned in previous sections flooding is the most common among all natural disasters. Especially during the last 50 years, where has been a significant increase in the period of rapid urbanization. Only in 2018, about 36 million people were affected by the flood. Between 1900 and 2018, the total loss exceeded 79 billion dollars.

Flood disaster has taken many countries many times under the influence of human life, especially economic and psychological. Although floods are experienced all over the world, they are more influential in developing countries, where there are a high population density and low economic coping skills.

Table 3.2. Flood disaster statistics per continent
(Source: EM-DAT, 2019)

Continent	Occurrence	Total Deaths	Deaths Per Disaster (%)	Total Affected	Total Damage ('000 Us$)
Africa	991	29,140	29.4	79,818,632	9,153,888
Americas	1,150	105,532	91.7	98,079,298	134,670,642
Asia	2,075	6,835,501	3294.2	3,613,336,172	491,164,330
Europe	614	9,454	15.4	16,793,990	142,223,586
Oceania	143	563	3.9	1,289,527	15,308,775

When the distribution of flood disasters by continents is examined, it is seen that it is mostly observed in Asia. In addition, the death rate per catastrophe in Asia is 3294 loss people/disaster while America is only 91 loss people/disaster which is the closest. To give a few examples of floods in the Asian continent (Table 3.2).

In 1974, flood disaster in Bangladesh spread to half of the country and took over the areas where it spread for a month. According to official records, at least 1200 people lost their lives directly, 27.500 people died of hunger and diseases due to the ongoing effects of flooding. Approximately 425,000 houses were destroyed, and the total loss exceeded 325 million dollars (Perez et al., 1986).

The losses in China's Yellow River due to the catastrophes that have occurred due to the unique form of the river are not equivalent to deaths occurring anywhere in the world. In only three floods since 1887, 6,000,000 people lost their lives (Perez et al., 1986).

In worldwide, the examination of disasters' statistics according to HDI illustrates that disasters happen all over the world regardless of their locations (Table 3.3). However,

Table 3.3. Disaster statistics according to the human development index
(Source: WDP, 2016)

Human Development Index (HDI)	Total Disasters (2006-2015)	Total Death (2006-2015)	Damaged (In Millions of US Dollars)
Very High HDI	1,119	48,138	843,386
High HDI	1,869	198,559	433,096
Medium HDI	1,535	86,753	101,071
Low HDI	1,567	438,461	45,261

low HDI countries are the most affected ones according to a number of people killed by disasters. On the other hand, other countries that have very high HDI have most damage economically (WDP, 2016).

3.4.1 Flood Events and Loses in Turkey

In Turkey, the topography's mountainous structure and it is high inclination accelerate the movement of the precipitation water. In particular, the transition from rainfall on bare land to the soil cannot be provided, therefore it manifests itself as the surface flow. In other words, our country is very suitable for the flood disaster due to its climate zone and geological structure (Basin Flood Control Action Plan in Turkey, 2013-2017).

According to the data of Emergency Events Database (EM-DAT, 2019) (Table 3.4); in order to take place in the disasters experienced in our country, disasters must comply with at least one of the database criteria. According to the records from the 1900s to the present day due to a total of 41 recorded floods in our country, 1359 people lost their lives, 214 injured, 1,785,020 people were affected by the disaster and caused a total loss of 2.2 billion dollars.

Table 3.4. Total disaster statistics in Turkey between 1900 and 2015
(Source: EM-DAT, 2019)

Type of Disasters	Occurrence	Total deaths	Total affected	Total damage ('000 US$)
Earthquake	78	89,236	6,924,689	24,685,400
Flood	41	1,359	1,785,020	2,195,500
Landslide	13	463	13,587	26,000
Storm	10	98	13,909	602,200

Within the scope of this thesis, investigations on the basin and river floods will be conducted. Riverine flood is the most common hydro-meteorological disaster. According to the data of the General Directorates of Disaster Affairs (GDDA), a flood incident occurred in all provinces except Kırklareli. Also, in the national database, the total number of flood incidents since 1955 is 4067. A total of 22157 victims in 80 provinces were affected by floods (Taşkesen, 2011).

According to the State Hydraulic Works (SHW) data, which contains only major floods, 1232 people have lost their lives in the last 50 years, and about 23 million hectares have been affected by flooding (Gökçte et al., 2008).

According to GDDA, İzmir has the highest number of flood events with Bartın, Trabzon, Hatay and Gaziantep between all provinces, distribution of events as shown in Figure 3.5.

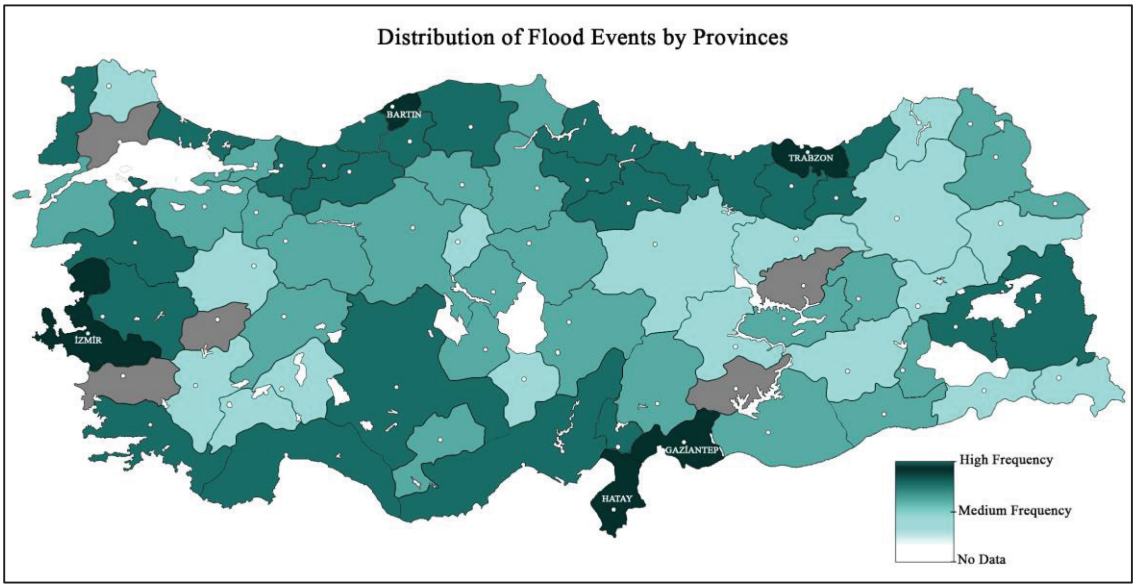


Figure 3.5. Flood disaster distribution in Turkey by provinces
(Source: Balaban, 2009)

The Number of information provided by the research represent that natural hazard and flood is a phenomenon that cannot be ignored. Especially flood is the most common natural disaster worldwide during the past decades and generates many environmental, economic and social consequences. Therefore, defining flood hazards, preparing flood risk maps and determining mitigation strategies have crucial importance to prevent the hazards turn into disasters.

In the previous sections, the concept of flooding, its causes, and effects was examined. In the next section, examples of measures to be taken against the catastrophe or risk of flooding will be given.

3.5 Mitigation and Resilience Strategies

In many countries around the world, structural and non-structural ways are applied to deal with disasters. However, firstly, vulnerability should be reduced as the first rule for coping with disasters. For this purpose, it is necessary to identify the areas under flood risk and to eliminate risks with comprehensive flood management planning for the groups under risk (Koyuncu, 2010).

Around this topic, some of the precautionary policies identified by FEMA are as follows:

- Determination of 100-year flood areas
- Floodplains should be cleared from settlements and turned into green public spaces.
- Transportation of areas under constant flood risk
- Construction of water sets
- Planning of the place where the accumulated water will be directed as a result of the sets

It was stated that the measures to be taken for the flood disaster were classified as structural and non-structural, and non-structural precautions can be shortened into four basic items:

- Establishment of emergency planning and warning systems
- Increasing awareness through campaigns and reducing risks with urban administrations
- Taking precautions that prevent or mitigate flood risk with Land Use Planning
- Identification of post-disaster insurance policies for rapid recovery (Jha et al., 2012).

For the structural measures, it is possible to briefly refer to the sets, dams to reduce the flow, ponds to lead water that accumulated because of dams, etc. However, these type of measures are traditional and at the same time costly mitigations strategies. In addition, FEMA stated that the economic and social damages of the flood disaster are increasing day by day although many measures are taken which structural (Turan, 2013). The next image shows some of the examples of structural measures (Figure 3.6)

In other words, flood disasters cannot be prevented from occurring in cities despite many infrastructure measures such as levees, dams, and channelization. This is due to the inadequate risk mitigating effects of flood control structural arrangements in the face of uncertainties in climate change. The flood control measures that cities rely on can only prevent floods by a certain amount of level. For this reason, cities are vulnerable even if they have taken infrastructural measures. Therefore, it is necessary to establish social and economic boundaries in which cities can flex or resilience in the face of disaster (Liao, 2012).

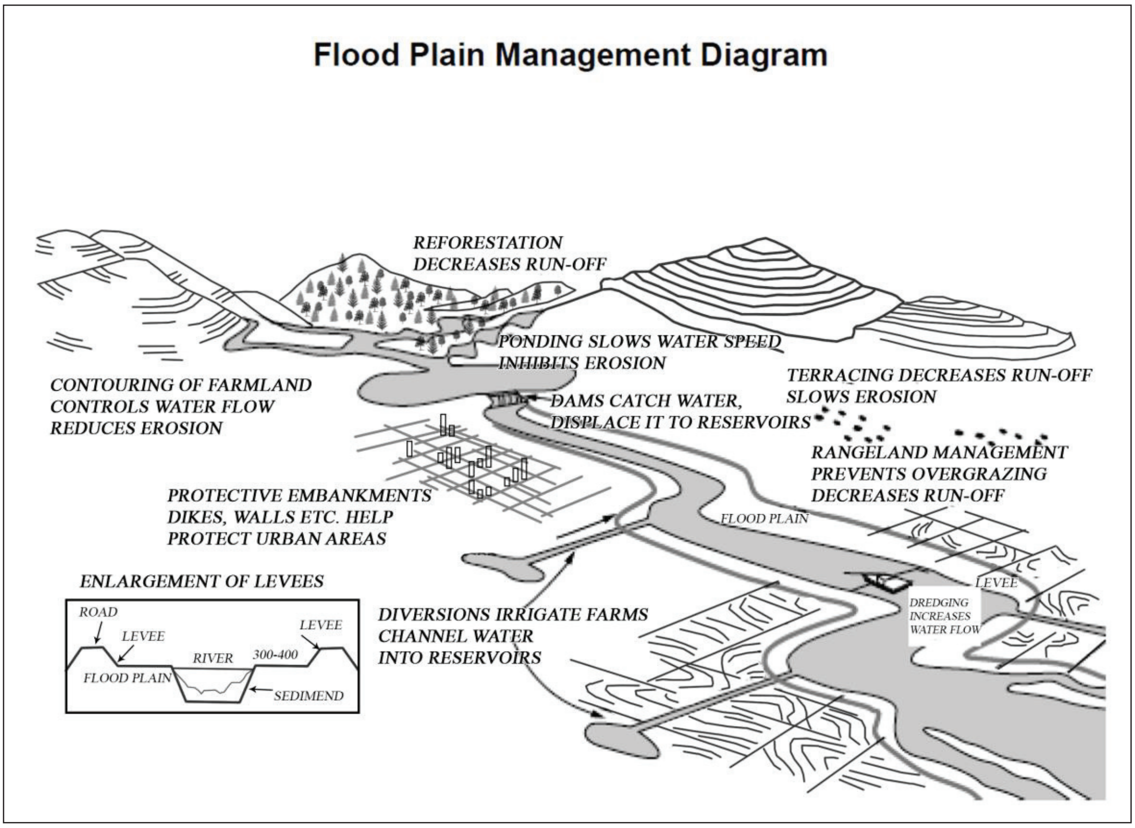


Figure 3.6. Structural measures for flood management plan
(Source: Jha et al., 2012)

It is possible to define urban resilience as the ability to tolerate disaster, to tolerate death and injury, to correct socioeconomic status, and to reorganize. In other words, it is measured by the flood size that the city can withstand until it reaches a threshold and passes through an undesirable regime. The desired regime; It is defined by a series of variables that reflect aspects such as livelihood security, economic performance, and mobility, which collectively represent the city's socioeconomic identity. The undesirable regime is characterized by considerably reduced resources and assets, large-scale population migrations, livelihood cuts, and security loss. (Figure 3.7 and 3.8).

For this reason, holistic preventive strategies should be determined in which the combination of structural and non-structural measures are provided while increasing the flexural share of cities against social-economic disasters. The following image shows a scheme of structural and non-structural work (Serra-Llobet, 2018).

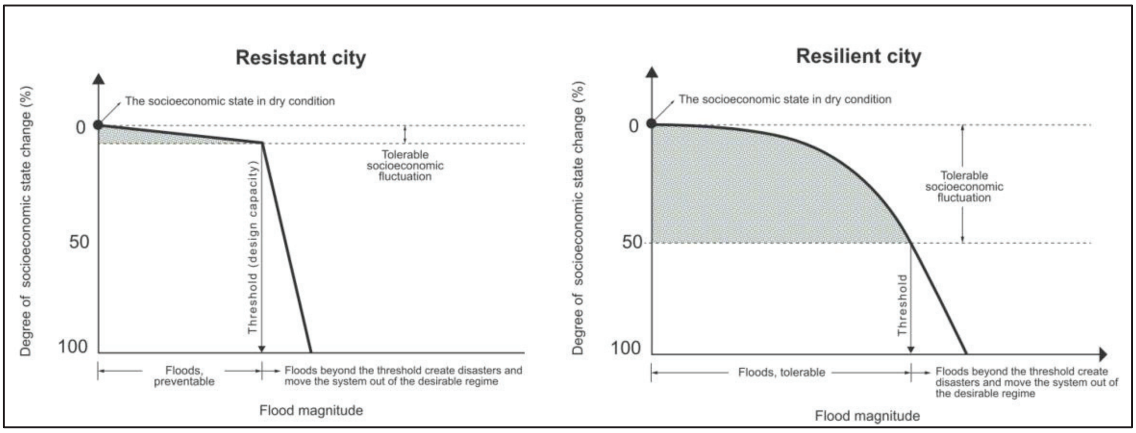


Figure 3.7. Resistant and resilient cities response demonstration against the disasters

(Source: Liao, 2012)

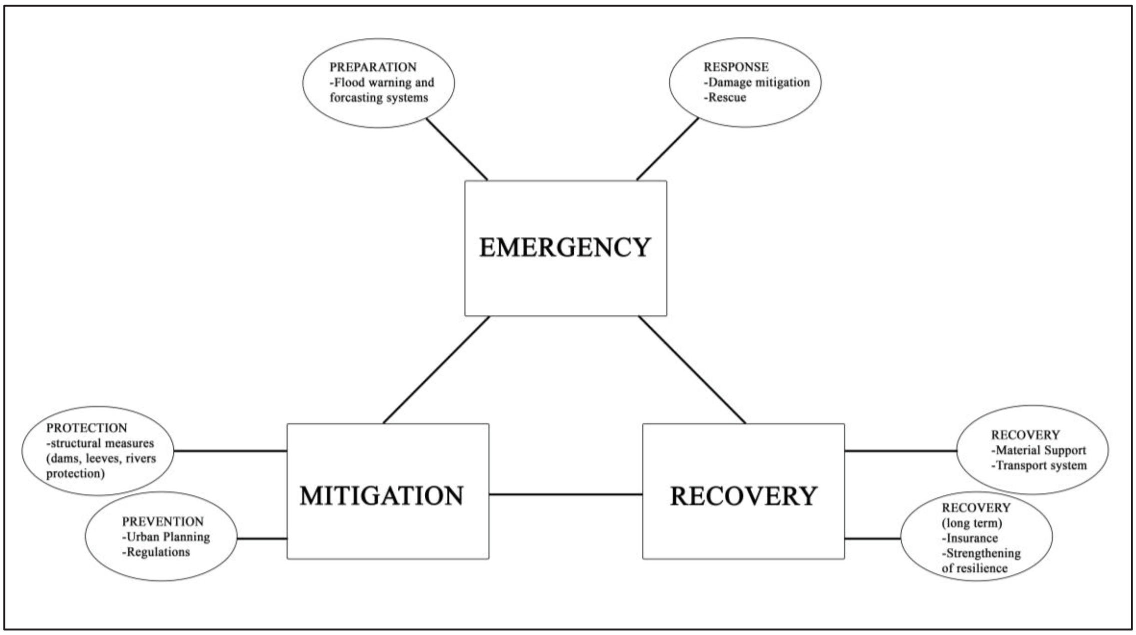


Figure 3.8. Flood management plan

(Source: Serra-Llobet, 2018)

So mitigation strategies of disasters are just one step, to achieve integrated flood risk management plan all three steps should be applied. Flood risk management plan is not only preventing disasters but also maintenance cities and safety of each individual citizen.

3.5.1 Land Use and Urban Planning

Today, irregular construction and industrialization, destruction of natural areas and deterioration of natural balance have caused increasing in flood disasters. For this reason, planning is vital in measures against disasters. One of the best examples of a combination of structural and non-structural measures is Urban Planning and Land Use-Planning. The determination of risks, the development of policies and the preparation of the plans in this context can be characterized as non-structural and the spatial practices of the plans can be defined as structural measures. Therefore, Planning plays a key role in the management of urban risks. Especially in developing countries, sustainable planning understanding of the formation of new urban areas is very important in order to prevent the increase in future flood disasters. Moreover, urban planning should be integrated with natural disaster management in order to create sustainable and resistant cities. It aims a safe location, safe construction, and safe activities.

In order to take measures against the areas under risk of floods with urban planning, first of all, flood risk maps should be prepared. By conducting zoning studies for the areas under risk of flood, insecure areas can be transferred to development plans as flood-prone zones. In this way, while the regions at risk are not identified as urban growth areas, these areas can be transformed into public areas, parks, recreation areas, and bicycle paths. In addition, urban planning and land use planning can prevent the destruction of natural areas and fight against global warming, which causes an increase in disasters. This planning approach can be specified by adaptive planning which helps cities to become resilience against disasters, also adaptation strategies in terms of the disaster can improve cities' resilience. Consequently, adaptive planning is creating design to make cities more resilience with react climate change and environmental changing while urban areas continue to evolve or expand (Graaf, 2012).

However, this integrated urban planning process requires greater coordination between city governments, national governments, public sector companies, including utilities, along with meteorological and planning institutions, civil society, non-government organizations, educational institutions and research centers, and the private sector.

3.6 Urban Flood Mitigation Examples Worldwide

In this section, the measures taken in line with the flood disaster in our country and in the world are examined with a few examples.

The Netherlands is located in an area that is prone to floods and has been working to reduce floods with different kind of implications but mostly ditch for 100 years. However, 240.000 people had to be evacuated due to the floods after 1990, and therefore, changes in the understanding of the measures were made. In this direction, the Netherlands has managed to reduce the flow rate by restoring floodplain, without changing ditch levels. It was achieved after 2006 when the "Room for the River" started to implement which is a spatial and flexible project. This project includes four steps, and these are; *river bypass where urban development has constricted river flow, restoration of reclaimed land to the river and integration with protected parks, water retention through increased storage capacity of lakes; and dike relocation to relieve bottlenecks at urban centers and development of the floodplain for compatible land uses* (Rijkswaterstaat, 2006). Moreover, 30 different projects with this approach are made.

In Singapore, Active, Beautiful, Clean (ABS) agency was founded in 2006 to solve floods and water problems. More than 100 projects have been implemented in line with this program which includes such methods like; reducing obstacles to the water cycle with green infrastructures, the implication of green network and green corridor to provide clean water and large floodplains and spatial applications for the collection of rainwater to reduce floods. Therefore, urban planning methods that applied through this program in more than 100 projects are aimed to create flood-resistant areas. As a result, with this program, despite the increasing urbanization, the flood-prone areas were reduced from 3200 hectares to 30.5 hectares in the period of 1970-2016 (The World Bank Group, 2017).

In the USA too, green road projects have many aims such as flood protection, creating public space around the river, improving water quality, providing social activity options along the green line, and preventing pollution, etc. The Bayou Green Road Project, prepared in this direction, has had a positive social and economic return to the public. In addition, when the floodplain is transformed into recreation, there is a decrease in the disasters and the temperature values which is formed as a result of being equipped with walking paths, bicycle paths, parks, and many other activity areas (Kirmencioğlu, 2015).

In Turkey, **İzmir** was experienced because of heavy rainfall floods occurred with the waters that brought by the streams in Karşıyaka and Çiğli in 1995. In addition, due to the storm, the wind speed has increased considerably, so it has become more difficult for water to reach the sea due to the rising of the sea. As a result of the event, a total of 61 people lost their lives in Izmir, 322 buildings were destroyed, and 10,000 buildings were damaged by the water. After the disaster, erosion study and terracing were carried out in the region and measures were taken to reduce the flow rate of the water in case of heavy rain. However, only structural measures were taken in the area (Koçman et al., 1996).

In Vietnam, Da Nang experiences flood and drought disasters regularly. However, in 2015, the city developed a resilience action plan. The action plan includes four steps and these are; increasing capacity of study basin, redevelopment settlement areas away from risky floodplains, using green infrastructure in risky floodplains and regulations for flood resilient housing (100 Resilient Cities, 2016).

3.7 Previous Studies

Tiryaki (2014) studied the Sarıçay area of Çanakkale and used GIS techniques to determine flood risk areas. In this study, the author used six different criteria to calculate risk areas. These are; slope, aspect, elevation, geology, land-use, and distance from the river. Moreover, the author divided into five classes all criteria according to their effects on flooding. After all classification, the author calculated the sensitivity map of the flood by overlapping six criteria. Author's result map also classified as five from very low risk to very high risk to observation the risk areas clearly (Tiryaki, 2014).

Selçuk et al. (2016) have carried out studies to determine the risk of floods in the central districts of the province of Van. According to this study, six different criteria have been analyzed on GIS-based. These are; lithology, underground water table depth, slope, elevation, a distance of drainage and field usage. Authors considered as important factors are assessing flood sensitivity is active channel distance and slope. The results of the study showed that 39% of the region had high and high-medium sensitivity areas. It is stated that by authors the result of the study provided healthy information also applications against flood will play an important role in a more planned and healthy way. In addition, the authors mentioned that the hazard models would be more reliable with the inclusion of precipitation data in the analysis for future studies (Selçuk et al., 2016).

Stefanidis and Stathis (2013), examined the 365 km^2 area located in northern Greece to calculate flood risk. Based on their research, they took 6 natural factors into consideration. These are; land uses, geological subsoil, mean slope of the watersheds, mainstream bed slope, the shape of the watersheds, the density of the hydrographic network. As sub-criteria, they determined three different effects on flooding; slight influence, moderate influence, and high influence. Therefore, the 48% of the disasters caused by anthropogenic and 43% of those with natural factors were the result of the study. In addition, Authors mentioned that this study can be used by decision-makers to identify areas under flood risk, to define flood hazard and to organize projects to protect flood risk (Stefanidis and Stathis, 2013).

The authors carried out an urban flood risk project. They state that because of rapid urban growth and uncontrolled illegal buildings urban prone areas increased significantly. In this context, Gigović et al. (2017) investigates flood hazard in urban areas using by GIS. The location was Palilula near to the Danube River, and it is in the northern part of the Belgrade in Serbia. The risk determination methodology includes six criteria which are; slope, distance to the sewers, distance from the river, elevation, the water table, and Land-use map. Authors aimed flood risk management and specified that this map is the first step for development plans of a flood risk resilience (Gigović et al., 2017).

The authors made an analysis on the GIS program for the determination of the areas under the risk of flood in Çorum province. In the study; rainfall, land use, geology, elevation, slope, view, distance to rivers, the size of the lower basins and the lower basin shape were taken into consideration. As a result of the analysis, the equal spacing method was used for more significant visualization of the values. With the result, it is determined that 3% of Çorum province is very high and 25% is under high flood hazard. As a result of the comparison of flood inventory, it is determined that the map can be used in the forecasting of the areas that are in danger of future floods (Yılmaz et al., 2017).

Authors examined the northern part of Sukhothai in Thailand which is damaged by flood every year. The analysis carried out on GIS-based and authors have investigated six relevant physical factors for the estimation of flood risk zones. These factors are; rainfall amount, slope, elevation, river density, land use, and soil permeability. The spatial modeling has been conducted in a GIS environment during a period of 2009-2014. The resulting map classified as five different divisions from very low to very high and it shows that southern parts of Sukhothai are sensitive for the flood that mainly caused by rainfall intensity (Seejata et al., 2018).

Ouma and Tateishi (2014) the authors intend to estimate floods in growing urban areas through this study. As a study area, Eldoret Municipality is located Uasin Gishu County has been selected which is expanding 20 times in the last 100 years. Criteria may cause floods has been determined as; rainfall distribution, elevation and slope, drainage network and density, land-use/land-cover, and soil type. These six criteria are graded in order of importance, the least important and the most important one is rated as 1 and 5, respectively. Also, six criteria divided into five class, in this context urban-land-use classified as commercial, industrial and transport, residential, admin-public utilities and educational use lastly agricultural use. The six criteria were analyzed on GIS-based with overlapping all different factors and result map classified from very low to very high for better visualization (Ouma and Tateishi, 2014).

Authors examined the Bashar River which is downstream of Yasooj city to determine the areas with the potential of flood hazard by comparing the hydrological models. The authors, who carried out analyzes with the weight assigned to the factors affecting the formation of a flood, said that GIS and RS techniques made a great contribution to the determination of flood areas. In this direction, the most important factors in determining the flood areas are listed as follows; slope percent, distance from rivers, land use/land cover and altitude. These five criteria are rated in order of importance, the least important one is 1, and the most important one is rated as 5. The resulting map divided into three different classes as low-medium and high-risk areas. Based on the study result the authors concluded that weighted overlay and GIS applications increased reliability (Rahmati et al., 2015).

Authors aimed to determine urban flood risk zone in Sungai Sembrong using by GIS. In this direction, authors specified the criteria of flood risk estimation with using previous studies which are; digital terrain, rainfall, flow direction, flow accumulation and catchment areas. Through the area investigation, elevation determined the most important criteria within the five of them. As a result of the analysis, 16% of the study area is defined as the area under the flood risk potential. Authors stated that decision-makers should take action such as not allowed to settle in flooded areas or floodplains and take flood prevention measures considering that this study has successful consequences for determination of flood-prone areas (Bukari et al., 2016).

Özkan and Tarhan (2016) studied to predict the potential flood hazard risk areas. They examined the province of Izmir and the main rivers in the study area. In order to calculate flood risk areas in İzmir authors determined five different factors which are effect flooding. These are; flow accumulation, land use, slope, rainfall intensity, and elevation. All five criteria divided into five sections to make the flood risk areas more understandable and overlay the factors using by GIS. They stated that the result can be used in planning studies and also with the use of high-resolution digital elevation map, it is possible to make lower error margin analysis (Özkan and Tarhan, 2016).

Authors studied lower part of Markham River in the Marobe Province in Papua New Guinea. In order to create or calculate flood risk, the selection of useful parameters is significant. In these direction authors specified all parameters and their individual class, parameters' rating assigned user-defined but their importance on flood risk. Therefore, while the close distance to the river gets highest risk rate, far distance to river gets lowest risk point. After all rating, overlaying factors carried out on GIS by authors, and result map classified into five categories as; no risk, low risk, medium risk, high risk, and very high risk. Lastly, the authors stated that this study could be improved and more reliable after adding many more flood effect factors such as rainfall, surface runoff, etc. (Samanta et al., 2016).

Turan (2013) examined how the natural thresholds of the flood plains disappeared over time and into the city because of lack of awareness and expanding cities, also mentioned flood protection methods in legal and planning dimensions. As a study area author investigated Silivri, Istanbul. While specifying the measures that could be taken against this region, the author firstly stated that Flood risk maps should be prepared and these maps should be taken into consideration in the improvement of development plans. Also mentioned that structural and non-structural measures identified by FEMA could be applied for mitigation measures. Lastly, areas which are under the flood risk, with the help of urban planning should transform public usage areas such as; green corridors, recreation areas, parks and etc. This floodplain area not be allowed for settlement; on the contrary, should design for people's social life activity (Turan, 2013).

Koyuncu (2010) accept the increase in the frequency of flood disasters due to the increase of uncontrolled settlements, increase in population and climatic changes on a global scale. Therefore, it has to be acted with sustainable environmental awareness. In this context, it is crucial that planning should supply flood resilience areas that protect people from disaster risk. Authors determined the parameters as follows; Determination of flood risks and open points against them, analyzing, increasing the resistance to disasters, mitigation, restructuring plans and dissemination of insurance-supported settlement logic (Koyuncu, 2010).

The author stated that the urbanization process has the greatest negative impact on floods. Therefore, he stated that hypothetical planning and design decisions should be taken to guide planning and space organization in risky urban areas. Also, he stated that disaster master plans and flood risk mapping should be done for cities within the scope of fight against disaster. According to the author; these risk maps should be considered as one of the priority values in the threshold analysis and the settlement's location decisions should be given accordingly, structures in risky areas should be evacuate in the medium and long term, and these areas should be used only for recreational purposes. In this perspective, in the primary risk areas no construction should be allowed and should use only for recreational purposes (Yazar, 2007).

The authors stated that flood risk management measures need to be comprehensive and integrated. Because of the location of local authorities, they could make better decisions. They also mentioned that urban flood risk management should linked with; poverty, climate change, housing, urban planning and urban infrastructure. Therefore, powerful solutions can provide flood risk mitigation, while at the same time create resilient urban development. As a result, the paper shows that integrated flood risk management with all actors could be successful and create resilience cities. In this context, they determined twelve key principles for integrated urban flood risk management (Jha et al., 2012).

Tingsanchali (2012) has collected the urban floods under two headings which are natural factors and human factors. Where heavy rainfall is a natural factor, deforestation is human factors. In this direction, the author mentioned that there are many mitigation strategies that applied around the world such as structural and non-structural measures. However, even though many measures are taken there are still flood disasters examples and it is increasing. Therefore, the author stated that structural and non-structural measures should be applied as a whole in order to be successful in these methods. Furthermore, the author divided resilience strategies into five and these are *1) preparedness before flood impacts such as flood forecasting and warning; 2) readiness upon flood arrival; 3) emergency responses during flood impact and; 4) recovery and rehabilitation after flood impact.* In addition, in order to achieve success through the implementation of multi-purpose measures, the public should be in all the risk management process from planning to implementation (Tingsanchali, 2012).

The authors stated that flooding is the most common natural disaster and have the highest damage on people's life and economy. For the countries who try to be "flood resilient" they should have sufficient capacity to resist, recover and adapt. Based on authors' international research, they determined six key governance strategies based on flood resilience. The strategies shortly are; diversity on flood risk management, public and private partnership, legal regulations, financial and other resources and etc. They aimed, these integrated strategies and findings may also be valuable lessons of climate adaptation more generally for the governance (Driessen et al., 2018).

CHAPTER 4

CASE STUDY

4.1 Description of the Study Area, the Menemen Plain, İzmir

The Study area; the Menemen Plain and its surroundings are located within the boundaries of the Gediz Basin and 35 km away from İzmir city center. The Gediz River Basin covers an area of approximately 1,713,697 hectares and is located between 38^{o}04’ 39^{o}13’north latitudes and 26^{o}42 - 29^{o}45’ east longitudes. The Gediz River rises from the foothills of Murat Mountain (Kütahya-Gediz) feeding by many streams coming from north and south and discharges to the Aegean Sea (Basin Flood Control Action Plan in Turkey, 2013-2017).

The length of the Gediz Plain formed by the Gediz River which changes its beds frequently during the flood periods is around 150 km, and in some places, it is 20 km in width. The alluvial base of the study area is determined by Bakırçay from the north, Menderes from the south, and Emiralem neck west of Manisa. Historical background of the Gediz River also referred its unstable flow. Especially Menemen part of the River was the most risky areas for flood disasters that is why the name of “Mainomenos” was given to region which means furious in Hellenic language (Uhri, 2019). Therefore, as it is seen flood risk of the Gediz River is even known from ancient time and its power affect the region’s name.

The Menemen Plain, between Emiralem neck and the sea is defined as a study area according to historical background of the Main River and flood suitability of the area in terms of elevation, slope, land use and other criteria. However, its surrounding areas, which is in the boundary of the Gediz River Basin, is examined in the analysis to determine the risk areas effectively. For the plain; in the east, Yamanlar Mountain was limited while Foça mountainous terrain was limited in the north and the height of the plain above sea level was approximately 10.3 m (Arslan, 2010). Figure 4.1 shows which part of Turkey and the Gediz River Basin is the study area.

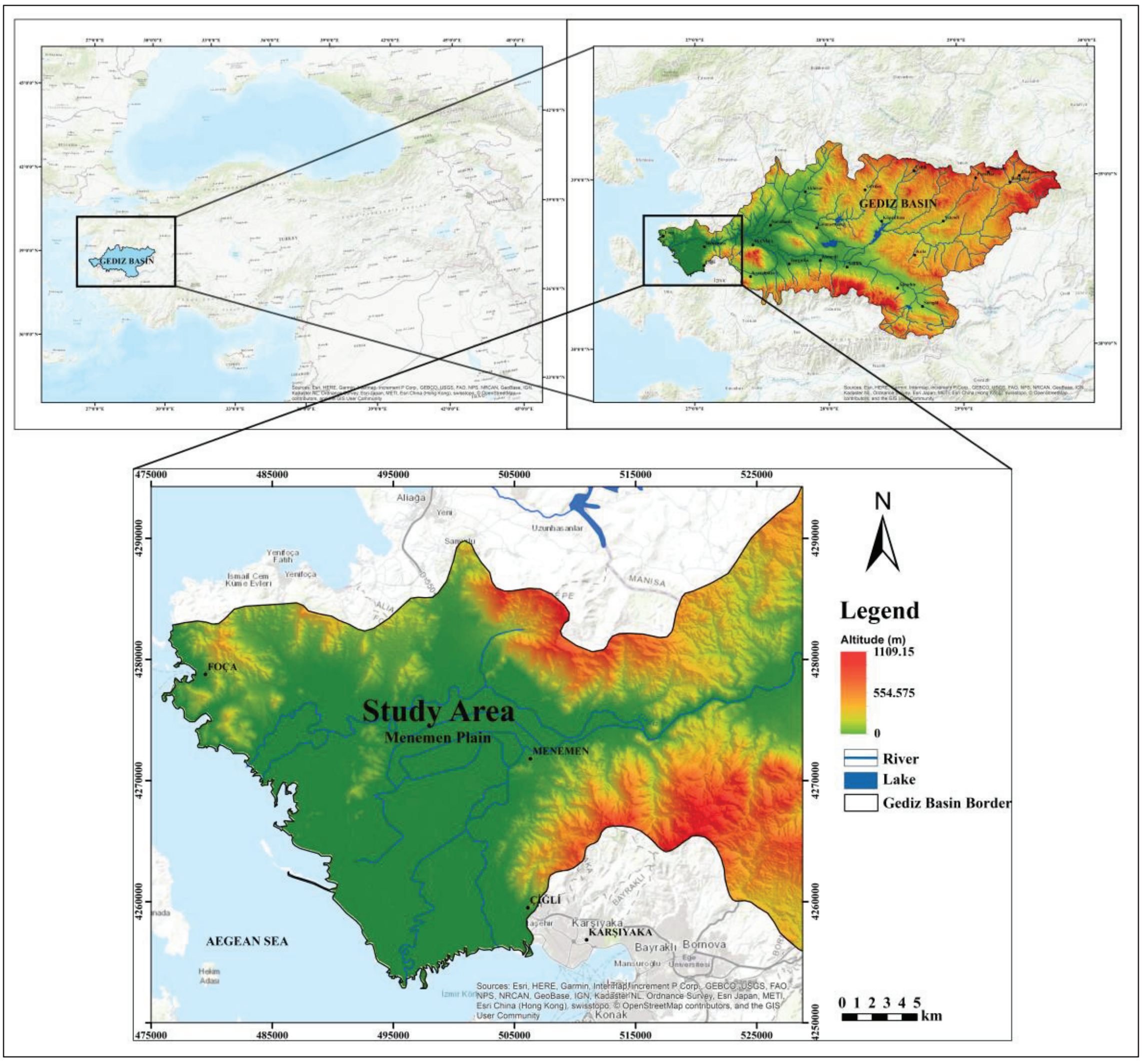


Figure 4.1. The study area location description

4.2 Climate of the Study Area

The Gediz River Basin, while the western and central parts of the basin are dominated by humid and semi-humid climates, the semi-arid climate is dominant in the eastern part. The average annual rainfall in Manisa is 708.0 mm and 688.3 mm in İzmir and 531.0 mm in Uşak (Basin Flood Control Action Plan in Turkey, 2013-2017).

Menemen, in general, has the characteristics of the Aegean Region climate. As the character of the area, the temperature approach to the temperature of tropical regions in summer. In terms of precipitation regime, rainfall in Menemen is mostly seen in winter months, such as the Aegean region rainfall including the Mediterranean precipitation regime (Arslan, 2010).

Within the scope of the thesis, monthly average rainfall data of the Menemen precipitation station were evaluated. The monthly average rainfall data obtained from the General Directorate of Meteorology is as follows (Table 4.1). The rainiest month in a 13-year history of the station is the tenth month in 2010 with 287.6 mm rainfall. It can be clearly seen that there is no regular pattern in terms of rainfall, it extremely changed in different years.

Table 4.1. Rainfall data of the Menemen precipitation station
(Source: GDM, 2018)

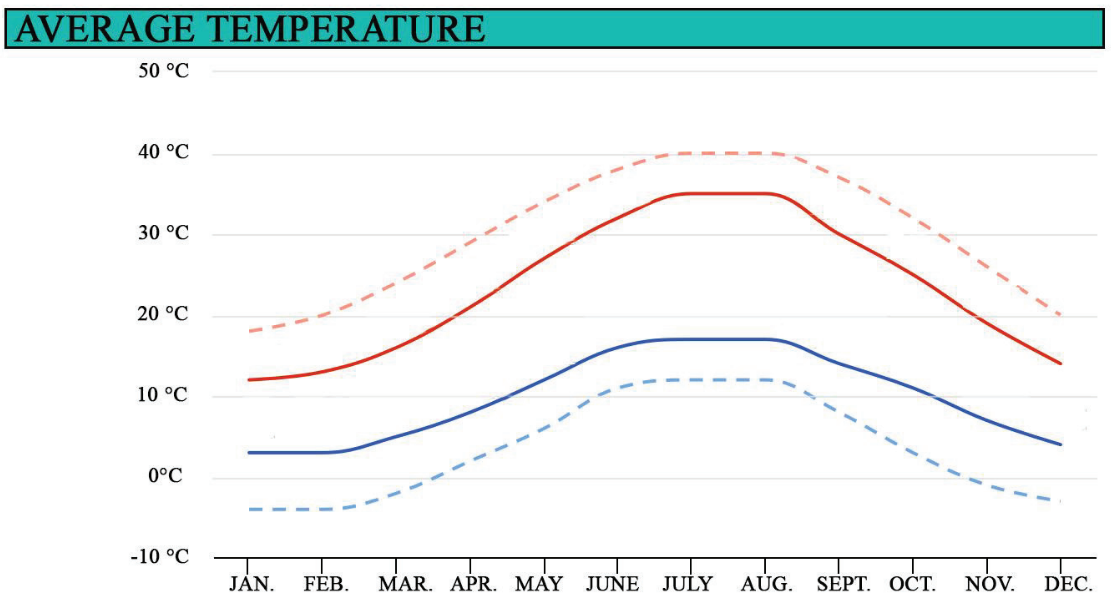
Years/Months	1	2	3	4	5	6	7	8	9	10	11	12
2006	45.4	36.6	98.6	14	2	0.8	2.8	0	20	61	24.2	6
2007	15.6	15.4	8	0.2	39.6	3.8	0	0	0	42.6	27	93
2008	17.4	4	55.8	49	6.8	0	0	0	25.6	13.4	74.6	58.8
2009	154.4	114	131.8	46.6	9.6	7.6	0	0	34.8	17	70	165.8
2010	97.2	211	21.6	51	23.4	16.6	7	0	28	287.6	19.6	59.6
2011	67.8	106.6	16.8	60.8	52	38.6	0	0	17	118.4	1	71.6
2012	70	100.6	39.4	49.6	82.6	19.6	0	0	0	5.2	27.6	157
2013	181.2	145.4	59.6	30.6	65.4	20.8	1.6	0	12.4	58.8	146	6.2
2014	98.2	13.2	70.6	80.2	7.2	29.4	0	0.4	14.4	35	14.2	185.8
2015	156.3	88.9	89.4	11.6	18.3	100	0	0	13	101.2	61.8	0
2016	169.7	55.1	118.8	17.8	17.2	4.8	0	0	0	18.9	76.7	10.2
2017	227.4	32.4	79	11.2	68.4	2.6	0.6	0	0	72.6	55.6	95.4
2018	112.6	111.8	65	3.8	9	74.4	0	0.8	4.2	18.4	94.4	109.2

The other climatic data of the study area is the average temperature of thirty years. The highest average value is 40 °C in the month of July and August (Figure 4.2). As mentioned before, temperature statistics are similar to the Aegean region climatic temperature pattern.

4.3 Geology of the Study Area

The general direction of the surface shapes in the study area can be defined as East to West because there is a significant elevation change. Yamanlar Mountain is located to the south-east of Menemen. Andesite masses are located on the foothills of this mountain which is spread northeast-southwest direction, while the eastern slopes of the mountain and the foothills of it have tuff with very low water-holding capacities.

When the soil structure of the study area is examined, it is seen that the areas with 1-6 m height have damaged or inadequately drained soils. As the altitude increases, the sandy and alluvial soils are replaced by clay with low water-holding capacities (Helvacıoğlu, 2003).



	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Mean Daily Maximum	12	13	16	21	27	32	35	35	30	25	19	14
Mean Daily Minumum	3	3	5	8	12	16	17	17	14	11	7	4
Cold Night	-4	-4	-2	2	6	11	12	12	8	3	-1	-3
Hot Days	18	20	24	29	34	38	40	40	37	32	26	20

Figure 4.2. Average temperature of 30 years
(Source: Weather History of Menemen, 2019)

The Menemen Plain was completely under the sea level and covered with water during the Pleistocene epoch. In first Holocene epoch, the Gediz River started to create its delta and in third Holocene epoch, the plain almost reached its form in today. Figure 4.3 shows the effect of the Gediz River in a time period that how it created the Menemen Plain. The numbers indicate the order of formation or shifting of delta distributaries on the Gediz Delta. Even though the Gediz River's last position is 8 with or without any implications, the some of the tributary of Gediz still works but some of them are just small and have a low flow rate (Hakyemez et al., 2013). In addition to that entrance of İzmir port would be closed with the filling of the bay by alluvium that carrying by the Gediz River. Therefore, main tributary of the Gediz River was changed by human interference to prevent accumulation of alluvium to Bay of İzmir in 1886. (Gediz, Bakırçay Basins Sustainable Strategy Report, 2015). However, the Gediz River has many examples that it changes its direction because of heavy rain and snow melting. In this perspective, some of the other parts of the river are considered as a risky tributary and the changing its way with human interference did not achieve its goal completely (Basin Flood Control Action Plan in Turkey, 2013-2017).

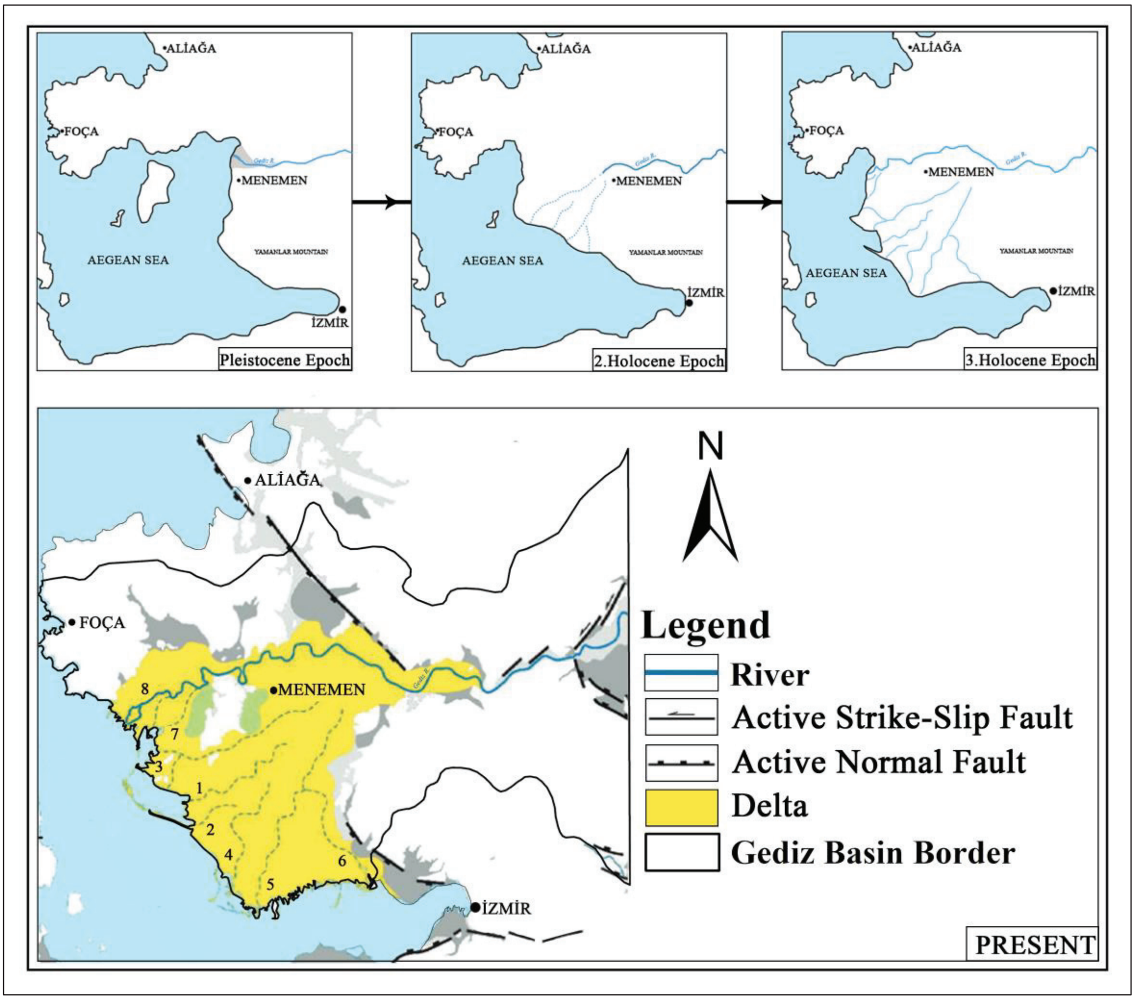


Figure 4.3. Transformation of the study area since the Pleistocene epoch (Source: Hakyemez et al., 2013)

4.4 Vegetation of the Study Area

In the Gediz River Basin which includes the study area, the forest contains many tree species such as chestnut, beech, oak, and alder. In addition, there are also widespread types of the maquis in the region. The rate of forests in Manisa province is 37.7%, in Uşak 39.8%, in Kütahya 53%, in Denizli 45.9%, in İzmir 39.7% (Arslan, 2010).

In Menemen, wide and hard coniferous, permanently green, drought-resistant trees and shrubs constitute the widespread-natural vegetation of the city like the Mediterranean Region vegetation. On the other hand, in the Menemen Plain, agricultural products are mainly; Cotton, Corn, Peach, Olive, Watermelon, Melon, and Spinach (Provincial Directorate of Agriculture Report, 2017).

4.5 1/25.000-Scaled Environmental Plan of the Study Area

İzmir Metropolitan Region Environmental Plan which includes the study area was examined. Two boundaries are noteworthy for the study area. The first one is flood zone which is showed by the red border also around the Gediz River and the second one is the wetland buffer area which is shown by a purple border. (Figure 4.4)

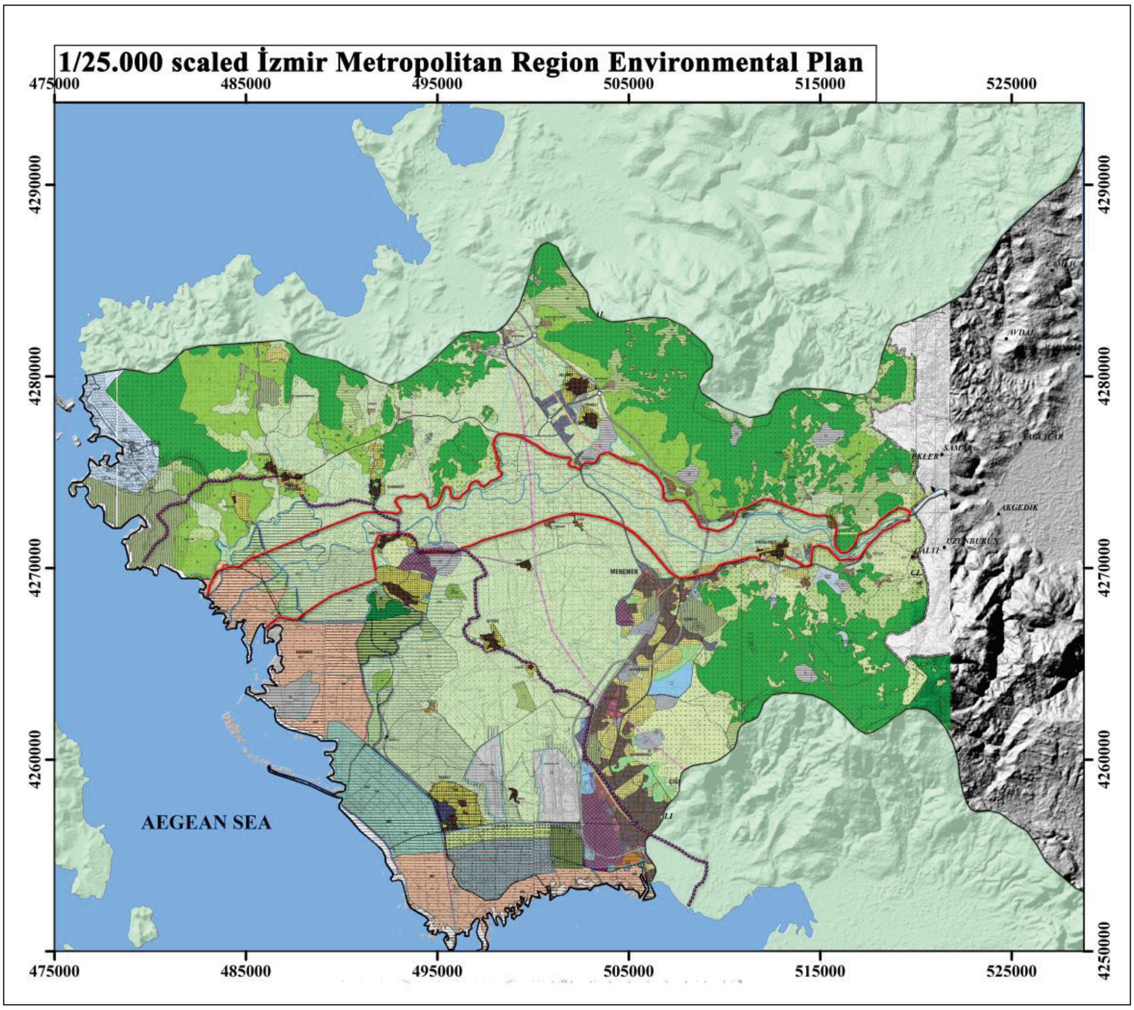


Figure 4.4. 1/25000-scaled environmental plan
(Source: İzmir Metropolitan Municipality, 2012)

The flood sensitivity area which is marked by red is determined with the plan's decisions. This area is set around just the main branch of the Gediz River. Even though the only determined area is around the main channel and other parts of the Gediz River did not considered, The Plan still offers new developments areas which are in that boundary. Not only this area but also wetland buffer areas have new urban development areas according to the plan's decisions.

In line with these decisions, new housing areas foreseen by the plan will be associated with the resulting map of the thesis after the risk assessment is completed. In addition, the area bounded to the flood zone will be updated according to the analysis to determine the flood risk areas to be made within the scope of the thesis.

For the other regions, as in the current situation, a large part of the Menemen Plain was determined as agriculture land by the plan decision. In addition, the ecological area indicated by blue border has been prepared by wetland conservation directive, and at the same time, the area is in the wetland buffer zone boundary. There are no settlements within this area, and it is defined as natural protected areas.

All these areas and all plan's decisions that relative to the thesis topic will be examined according to the resulting map of the study area.

4.6 Materials and Method

Within the scope of this study, analyzes for determining the flood areas were carried out, and the criteria used in the analyses were determined within the literature review. Therefore, reliable sources were used to provide the six criteria which are determined by the literature. These criteria include; (1) slope, (2) elevation, (3) distance from rivers, (4) distance from junction-points of river, (5) land use/cover, and (6) rainfall. In this direction, rainfall statistics were obtained from the General Directorate of Meteorology, and the other five criteria were calculated from two data sources. For slope and elevation analysis, The Aster DEM data of the area obtained from the official site of the United State Geological Site (usgs.com). For Land use/cover, distance from rivers and distance from junctions from rivers criteria data was obtained from CORINE Land use/cover 2012 data in Copernicus Land Monitoring Service (land.copernicus.eu). The CORINE data was updated by overlaying with the 2019 google satellite image and rivers also have been updated from google satellite image.

4.6.1 Data Processing

The purpose of the thesis is to determine flood risk areas and evaluating mitigation strategies for the area. For this aim, how analyses were proceeded works and how data sources were used are illustrated in Figure 4.5.

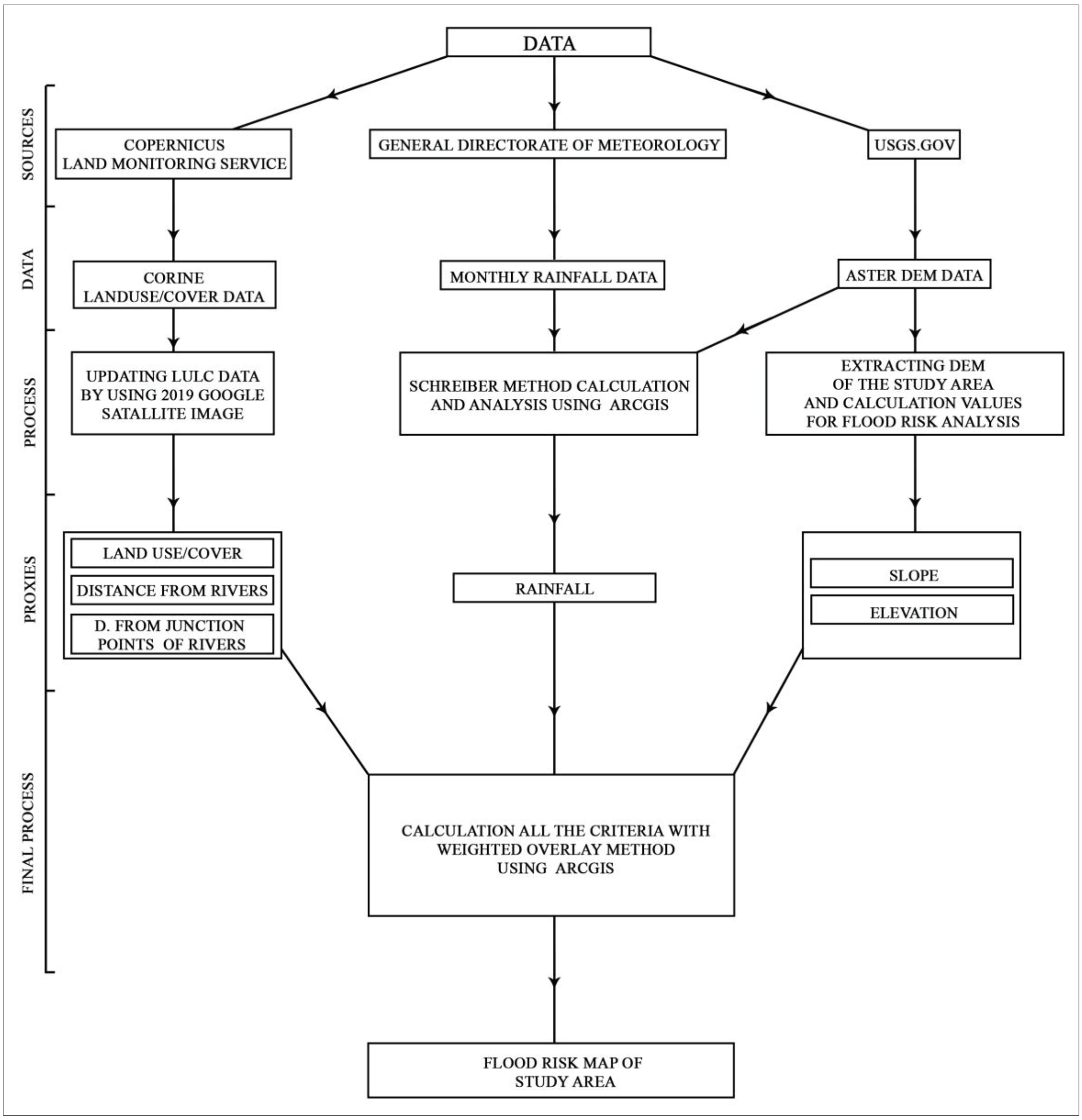


Figure 4.5. Data processing of the study

4.7 Proxies Used for Determination of Flood Risk Areas

Within the scope of the thesis, before the determination of criteria that affect a flood risk level, previous works were examined to specify these criteria. Although many examples used the same criteria in the literature review, it can be seen that because of the land differences, the number and weight of the criteria used were different (Seejata et al., 2018; Özkan and Tarhan, 2016; Rahmati et al., 2015; Ouma and Tateishi, 2014; Samanta et al., 2016). Therefore, six criteria were determined with the examination of the land investigation in the study. These proxies or criteria as follows; (1) Slope, (2) Elevation, (3) Distance from Rivers, (4) Distance from Junction Points of Rivers, (5) Land Use/Cover (LULC), and (6) Rainfall. The weighted values of the variables were used in the thesis are determined by literature research. However, as indicated, the number of weights can be showed differences between study areas according to regions or areas. Therefore, the effects of the criteria on the flood were taken into consideration in the literature, and the values were determined with the study area investigation.

$$\mathbf{FRA} = \sum_{i=1}^{n} W_i P_i = \mathbf{W_1P_1 + W_2P_2 + \ldots + W_6P_6}$$

FRA → Flood Risk Areas

n =6 → The number of the proxies

P_i → Proxies, i = 1...6

W_i → Weights of the proxies, weight coefficients range from 1 to 5. In this study all parameters and their individual class, parameters' rating assigned user-defined but their importance on flood risk with the help of the literature research.

The weights of the proxies were determined with literature review and land observations.

In the next section, all the six proxies and their method of calculation will be explained. For detailed information about the values of each criterion and class of each proxy figure in Appendix A can be examine. The figure shows proxies, intervals, weights of proxies and methods of calculation shortly. In addition to that color, the description can be observed.

4.7.1 Slope - Proxy 1

The slope affects the surface flow to a region, so it is extremely important in the flood events. It is easier to collect water on flat surfaces and this ratio is less in areas with a high slope. For this reason, considering these factors in slope classifications, high flood risk was assigned to a low degree of slope places and low flood risk was assigned to areas with a high degree of slope (Ouma and Tateishi, 2014). In this study, when the Menemen plain and its surroundings were examined, the slope map was created using by Aster DEM data in ArcGIS software. For the map spatial analysis slope tool was used in degree scale. After that slope change was observed with changing intervals of degree. In the last stage of classification of slope degrees, the investigation slope changing and the intervals in the literature were evaluated (Özkan and Tarhan, 2016). In the following process, the slope rating was divided into five classes from very low risk to very high risk. Five classes representing flood risk index was created with ArcGIS reclassify tool and five is assigned for the high-risk areas which have a low slope, where one is assigned for the high slow areas which are low-risk zones (Ouma and Tateishi, 2014). The indexes of the slope map represent these intervals; 0-3, 3-10, 10-25, 25-50, > 50 in slope degrees (Figure 4.6).

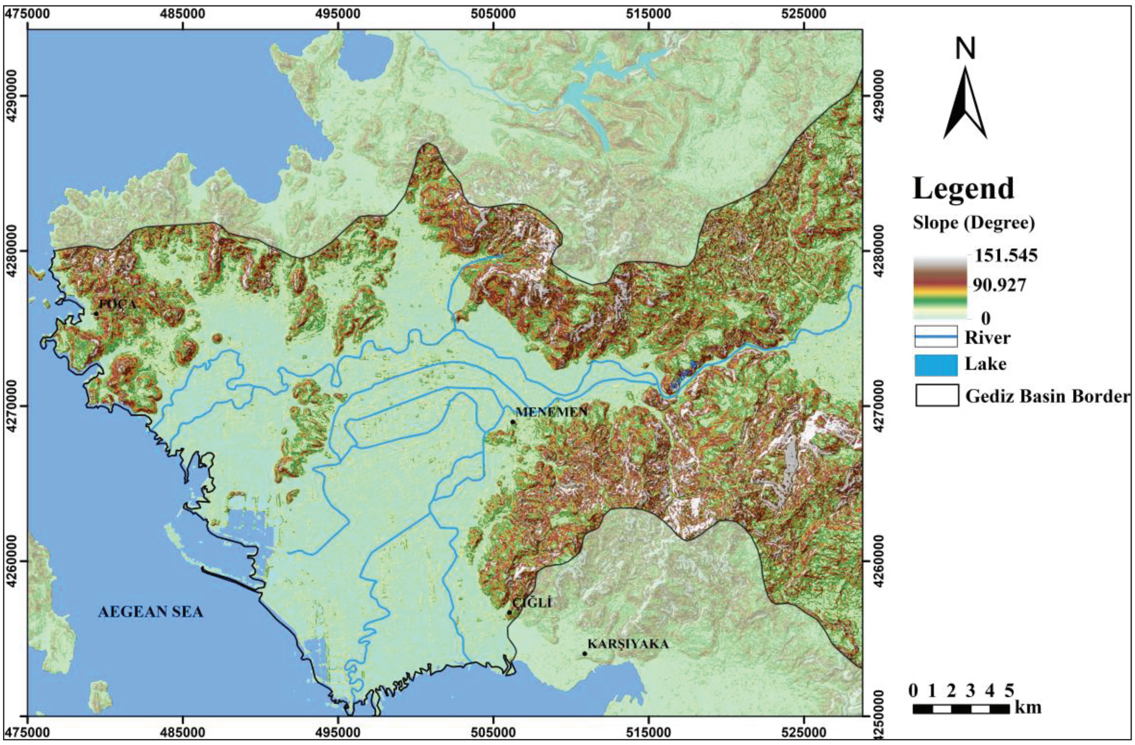


Figure 4.6. Slope map of the study area

Because of influencing water flow rate, effects on discharging water, especially with low altitude areas particularly in the coastal cities slope has a significant role in flooding. Consideration of all these situations, for the study area slope, has the power that caused flood events. For these reasons and literature research, 3.5 weight value was given to slope criteria (Eimers et al., 2000). For the case study area, the results of the original slope map and reclassified slope map with intervals and the FRI values are presented in Figure 4.6 and 4.7 and Table 4.2.

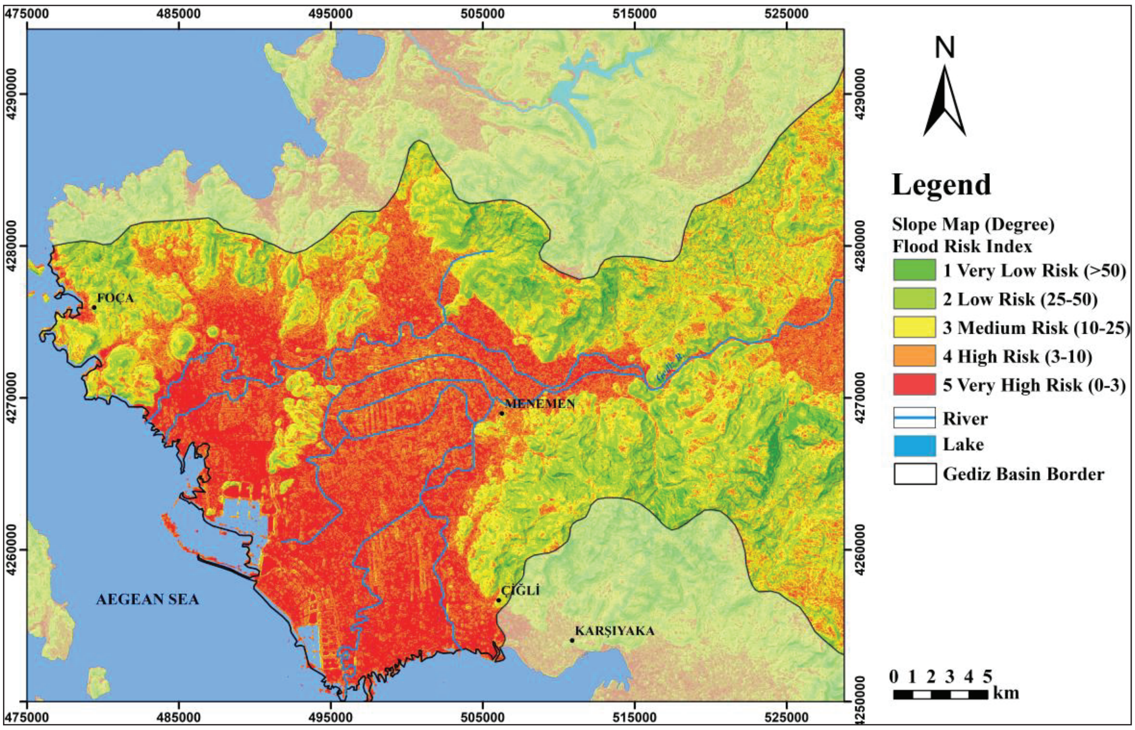


Figure 4.7. Reclassified slope map of the study area according to the FRI

When the slope map for the study area is examined, the area distribution according to the flood risk index is as follows:

Table 4.2. The FRI area distribution according to the proxy of slope

Slope (Degree)	FRI Values	FRA (km^2)
0-3	5 (Very High Risk)	283
3-10	4 (High Risk)	324.4
10-25	3 (Medium Risk)	305.7
25-50	2 (Low Risk)	217
>100	1 (Very Low Risk)	28.5

When the distribution of the area is examined; very high risk and areas at high risk appear to be dominant in the study area. While the whole plain is almost very high risky, the risk factor decreases as it moves towards mountainous areas where slope degrees are at an increase

4.7.2 Elevation - Proxy 2

Not only the slope criteria, but also the elevation criterion has an effect on collecting water and discharge especially in low altitude areas and low slope areas where water has no place to leave is the main causes of flood. Furthermore, it affects area also in the long term because of long-time of discharging process (Tiryaki, 2014).

The elevation map of the area was generated from the ASTER DEM image of the area using ArcGIS 10.2 software. When the elevation map is examined, it is seen that the height of the plain from the sea level is about 10 m. The elevation criterion is of critical importance, along with the slope for the study area, because it is surrounded by high mountains and the plains are so close to the sea level. Due to the high slope from the surrounding mountains, the water masses that come with the strong flow will not be discharged for a long time because of the low height in the area of the plain. One of the biggest reasons for this is that the elevation change in the plain is very low.

Height range distribution and variation of the field were taken into account in order to make the classification consistent after the elevation map was created. The elevation map was classified as very high risk, high risk, medium risk, low risk and very low risk within these researches. With the information provided in the literature, areas with low elevations are considered more risky and areas with high elevations are considered less risky (Rahmati et al., 2015). The result of the classification, for very high-risk index value 5 was assigned where 1 was assigned for very low-risk areas.

For the determining of the weight for elevation proxy. Study area and literature were investigated together (Özkan and Tarhan, 2016). The weight coefficient of the elevation proxy was assigned as 3.5 the fact that the Menemen Plain is only 10m high from the sea level allows for the accumulation of area waters due to the fact that it is surrounded by high mountains For the case study, the results of the original elevation map and reclassified elevation map within the five intervals are presented in Figure 4.8 and 4.9 and Table 4.3.

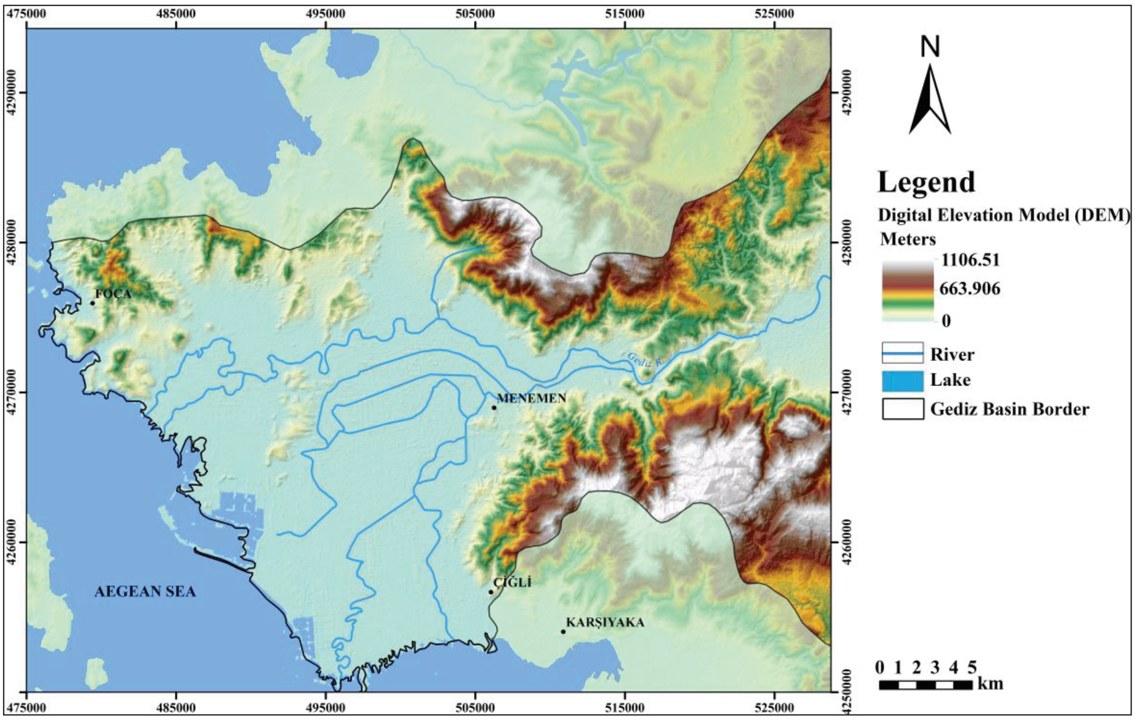


Figure 4.8. Digital elevation model (DEM) of the study area

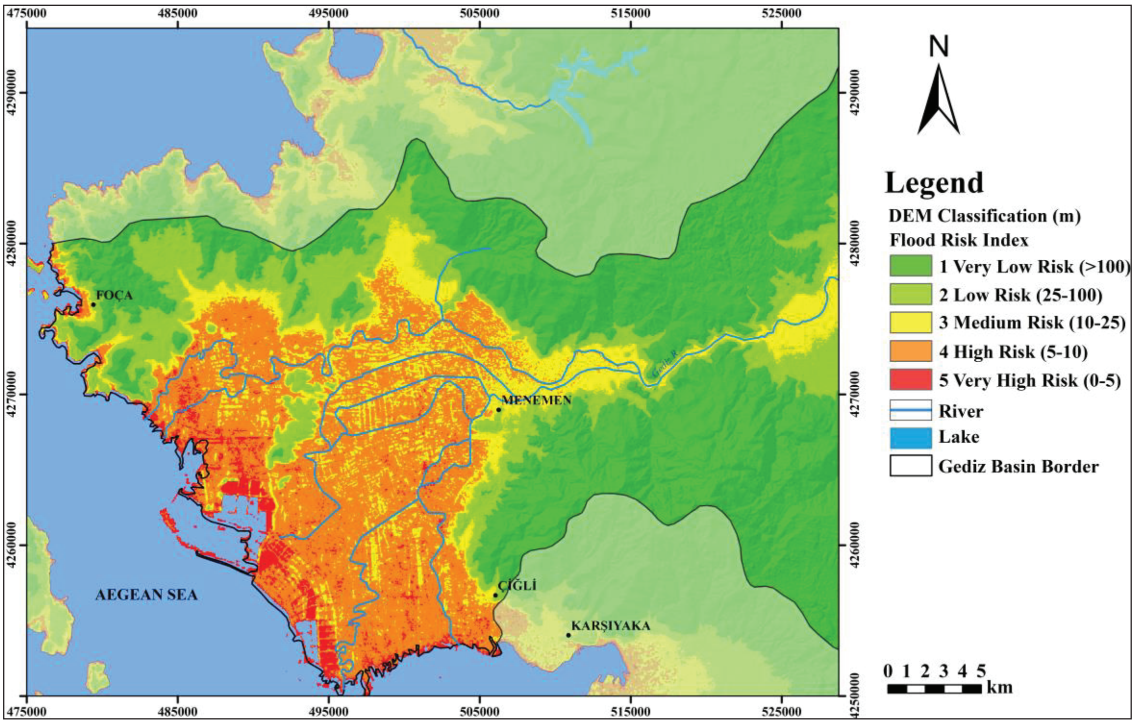


Figure 4.9. Reclassified elevation map of study area according to the flood risk index (FRI)

Table 4.3. FRI area distribution according to the proxy of elevation

Elevation(m)	FRI Values	FRA (km^2)
0-5	5 (Very High Risk)	38
5-10	4 (High Risk)	302.6
10-25	3 (Medium Risk)	151.6
25-100	2 (Low Risk)	175.8
>100	1 (Very Low Risk)	500.8

In the risk analysis performed in the direction of elevation, a large majority of the area was found to be low risk due to the mountainous region of Yamanlar, Dumanli Mountains and Foça surrounding the plain. The area which is considered as in very high risk and has 0-5 m elevations where the wetlands are located. In addition, the region, which is considered as in high risk, dominates the region except for mountainous areas. Moreover, compared to the Land-Use/Cover map, it can be seen that the 302 km^2 region, which appears to be in high risk, covers the regions where there are residential areas.

4.7.3 Distance from Rivers - Proxy 3

As mentioned in previous studies the 'distance from rivers' factor plays an important role in determining the flooding area (Fernandez and Lutz, 2010). The literature review also noted that river extreme runoff is one of the main reasons for the starting of flooding. Generally, areas near the river or water beds are considered to be the most risky regions because flood disasters start from river beds and affect their immediate surroundings too much (Gigović et al., 2017). For study are river data (Figure 4.10 and 4.11) obtained from the Copernicus Land Monitoring Service and were updated via ArcGIS base maps.

In this study, all branches of the Gediz River are examined that active in four seasons. In the event of a possible flood, considering the slope map and elevation map, it was observed that the flood waters that would be happened by the riverine flood could not leave the plain for a long time. In this context, for the purpose of the classification process, the river networks were first put into the Euclidean Distance analysis through the ArcGIS 10.2 program. The resultant map is classified as very high risk, high risk, risky, medium risk, low risk, and very low-risk areas. Five index values were assigned for the intervals. Five as an FRI value is assigned for the closest distance to the rivers which is determined very high risk where one is assigned for the very low-risk areas (Samanta et al., 2016).

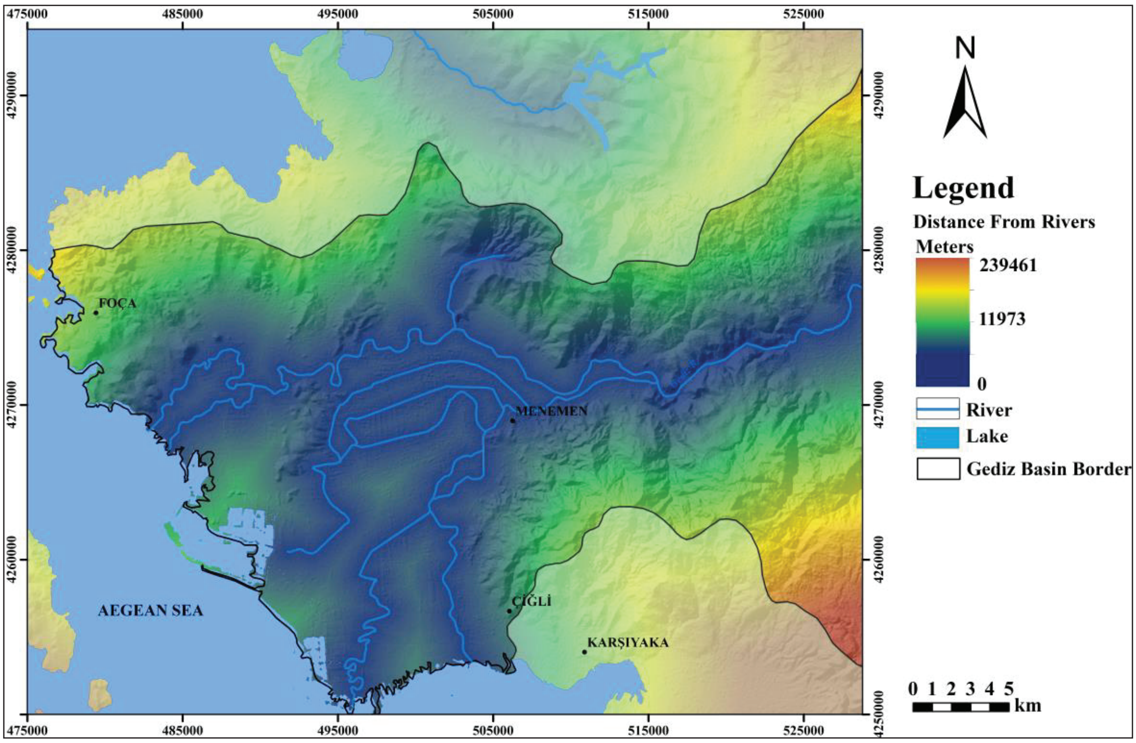


Figure 4.10. Distance from rivers (DFR) of the study area

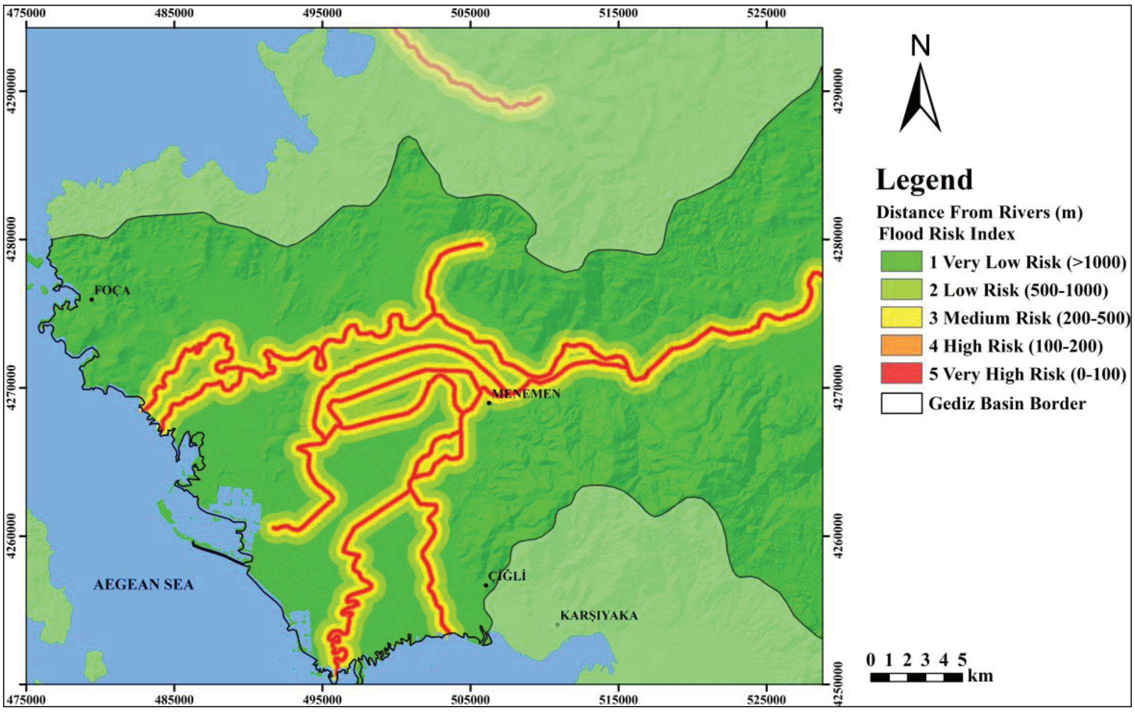


Figure 4.11. Reclassified DFR map of the study area according to the flood risk index (FRI)

In the weighting process; the starting point of the floods and due to the fact that there are many branches with the main the Gediz River in the study area. The weight coefficient of the distance from rivers proxy was assigned as 4.5 (Rahmati et al., 2015).

For the case study, the results of the original and reclassified distance from rivers layers are presented in Figure 4.10 and 4.11.

4.7.4 Distance from Junction Points of Rivers - Proxy 4

Around the river, beds are the areas where the flood risk is the highest. Because of the topographies of the study area, rivers pose a great risk in the area (Rahmati et al., 2015; Samanta et al., 2016). Especially the regions where the flow of the two rivers reach in a one way, the areas where they are connected with the sea and the areas between the high slope and high altitude of the river bed in a narrow area is one of the significant reasons that lead flood hazards. According to area investigation in the scope of the thesis, these points that have great importance in flood hazard are determined as a "junction". In other words, these regions were defined as connections where river branches converge, the river arm joins the sea, or the river branch remains low slopes and low elevation between the high slopes and elevations. As mentioned, junction points have been assigned to the risk of many variables depending on the flow changes at the junction points of rivers, especially in extreme precipitation. The analysis of the points determined in this direction was performed with the Euclidean distance tool in ArcGIS software. The criteria map that run out from ArcGIS are classified into five classes which area; 0-250 m, 250-500 m, 500-1000 m, 1000-2000 m and >2000 m. These five classes assigned as very high risk in close part of the junction points or very low risk in most distant areas (Rahmati et al., 2015). For this proxy, same FRI values are applied as previous ones. The factors causing the formation of riverine floods like increased flow rate, slope, elevation, etc. affect these points first. So these areas can be defined as the starting point of the flood. In this perspective, the weight coefficient of the distance from junction points of rivers proxy was assigned as 5 (Rahmati et al., 2015; Eimers et al., 2000).

For the case study, the results of the original map with convergent of the river and reclassified distance from junction point of rivers layers are presented in Figure 4.12 and 4.13.

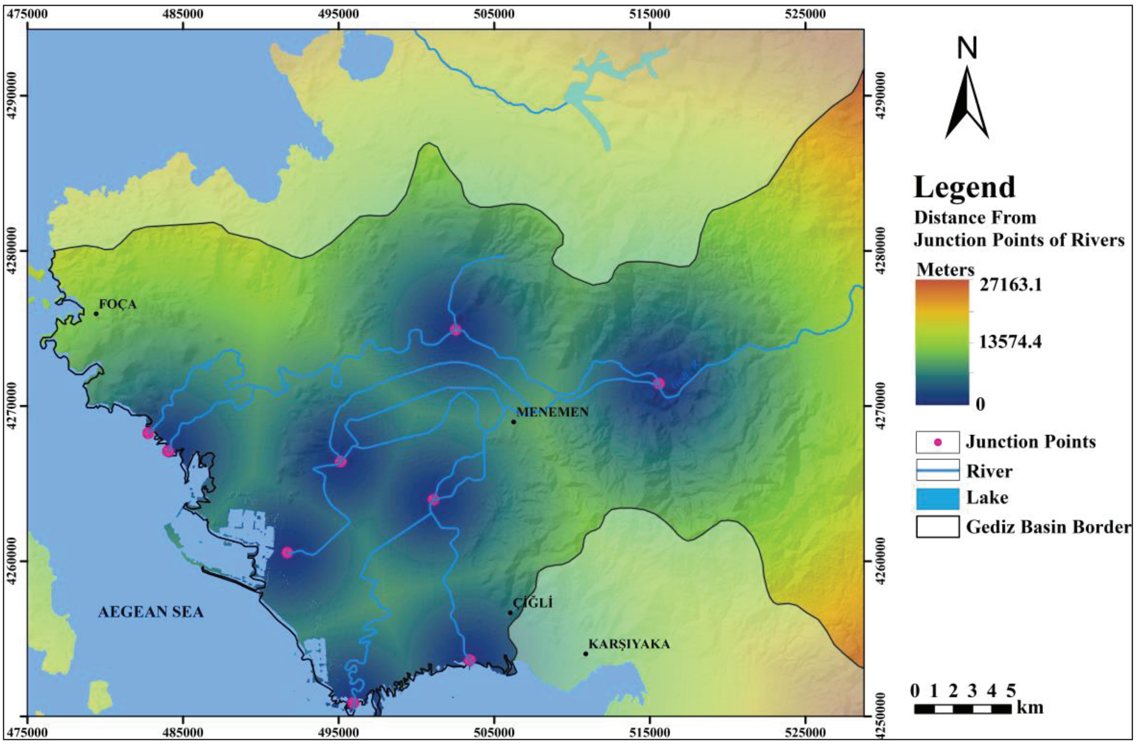


Figure 4.12. Distance from junction points of rivers (DFJPR) of the study area

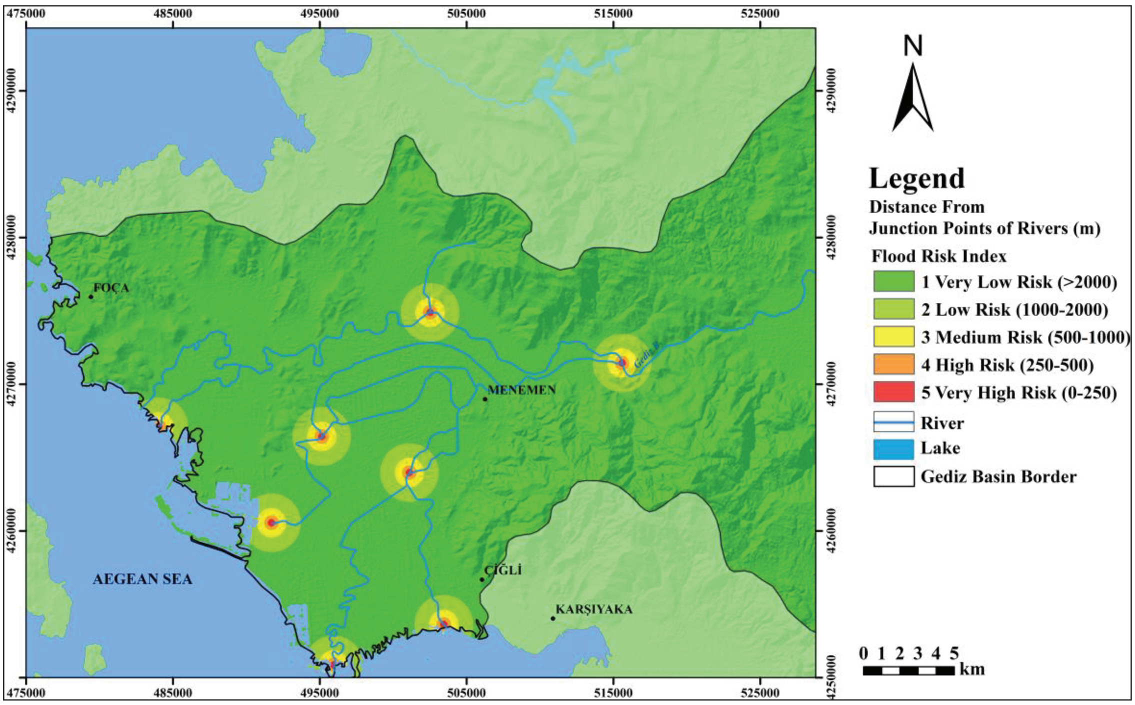


Figure 4.13. Reclassified DFJPR map of the study area according to the flood risk index (FRI)

4.7.5 Land Use/Cover - Proxy 5

The Land Use/Cover (LULC) criteria are also one of the important reason that should be considered when the calculation of flood risk zones. Land qualifications have effects such as the flow of water and the ability of the soil to absorb water. Urban and industrial areas (roads, buildings, asphalts) are fragile areas that hold water, reduce the absorption and accelerate the flow. On the other hand, forest areas or dense vegetation areas are less sensitive to flooding due to the ability of the soil to absorb water or reduce the flow (Rahmati et al., 2015). In this study, LULC data (Figure 4.14) were taken from CORINE Land Cover 2012 and the data was updated using the satellite images of 2018 via the ArcGIS program.

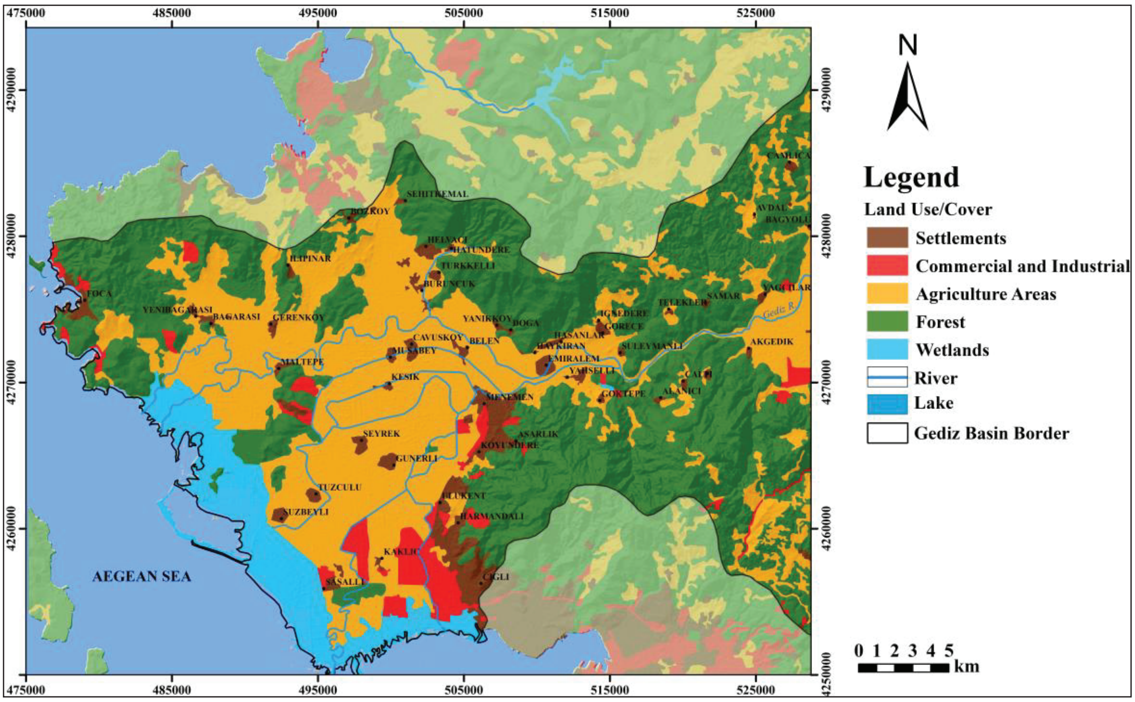


Figure 4.14. Land use/cover (LULC) map of the study area

The LULC map firstly classified according to the importance and some of the areas combined in layers that have the same effects on flooding. The map classified into five area definitions before the latest analyze which are; wetlands, forest, settlements, agriculture areas, and industrial-commercial areas. This five different definition and their risk values are determined with literature research. Therefore, Wet areas are defined as the most vulnerable areas, while forest areas are defined as the lowest risk areas (Seejata et al., 2018). Due to the alluvial structure and poor drainage structure of the agricultural areas that make up the majority of the Menemen Plain, it is determined as the most vulnerable areas after the wetlands. For the final map, FRI values are assigned as all proxies in the thesis, five was assigned for the most risky areas and 1 was assigned for the lowest risky areas. The weight coefficient of the Land Use/Cover proxy was assigned as 3 according to significance to the determination of FRI.

For the case study, the results of the original and reclassified Land Use/Cover layers are presented in Figure 4.14 and 4.15.

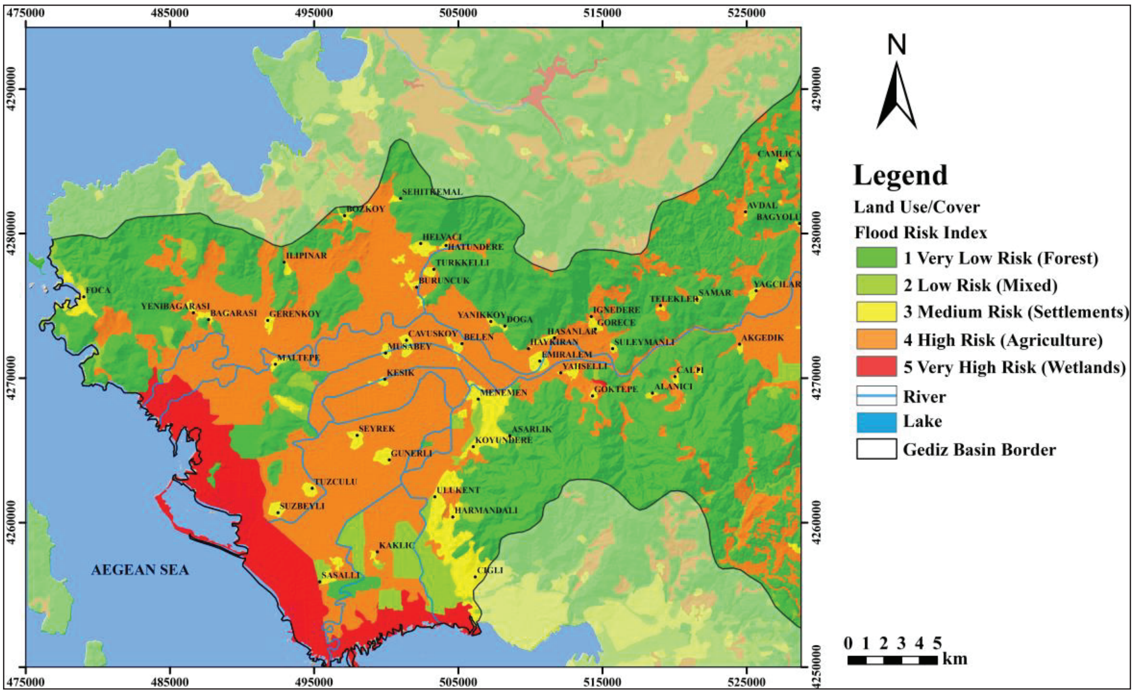


Figure 4.15. Reclassified LULC map of the study area according to the flood risk index (FRI)

4.7.6 Rainfall - Proxy 6

Severe precipitation is one of the main causes of flood disaster. Particularly, in the places that cannot absorb water enough and there is no place to evacuate are most vulnerable against the extreme rains. In addition to that extreme rains which is coming from high altitude with high degree slope causes increasing rivers' flow and rivers' levels (Ouma and Tateishi, 2014).

For the study area, monthly average rainfall data (Figure 4.16) of the last 13 years of the Menemen Rainfall Station were obtained from the General Directorate of Meteorology. The Menemen precipitation station is located approximately 8 m above the water level in the middle of the plain. Schreiber method was used to get an idea of precipitation statistics for the areas where the elevation is high.

Schreiber equation: Ph = Po + 54*h

Ph: Rainfall

Po: Rainfall of the station

54: Coefficient of precipitation in 100 m

h: Hectometer

The Schreiber formula is directly proportional to the elevation. In ArcGIS, contour lines created from Aster Dem file are converted to points with a split line at vertices tool. Then, the average rainfall statistics for the Po value for the months were calculated and the calculation result found out as 553.35mm. The coefficient for the changing in every 100m is used as 56 that for the Aegean Region (Aydinozu, 2008). The Schreiber formula applied to the field as follows:

average rainfall — changing in altitude

$$Ph = 553.35_{mm} + 56\left(\frac{x-8}{100}\right)$$

hectometer segment

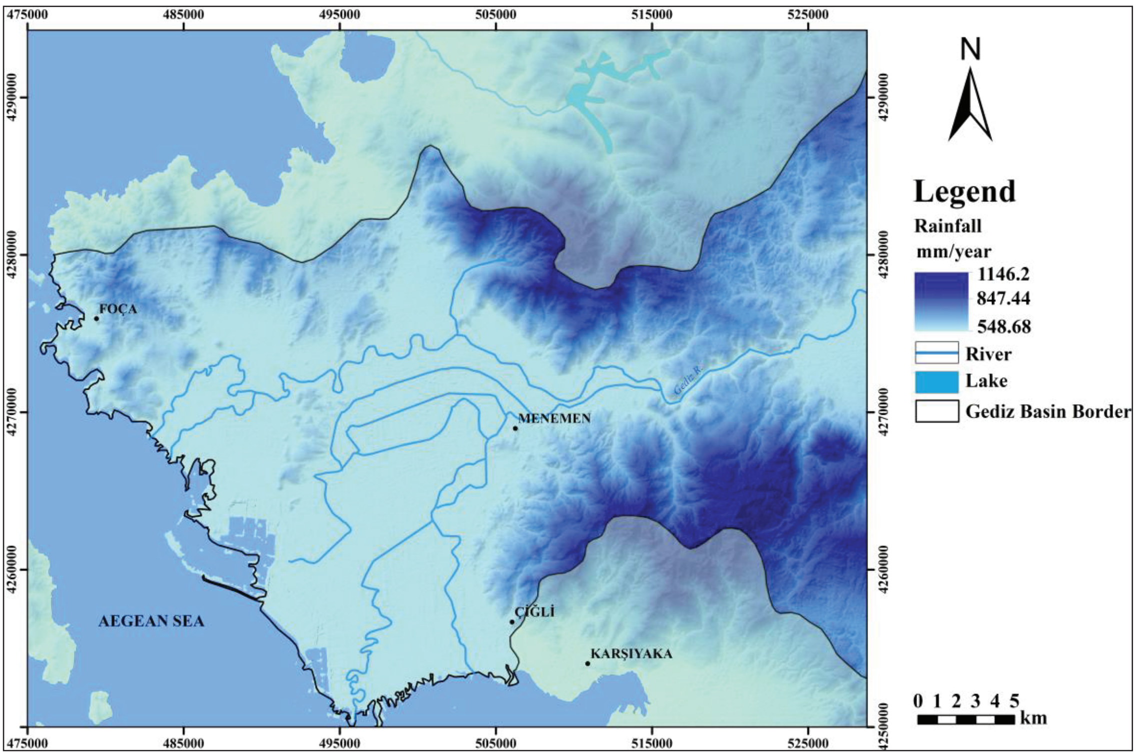


Figure 4.16. Rainfall map of the study area

Mean annual rainfall for 13 years (2006–2018) was considered and interpolated using Natural Neighbor (NN) to create a continuous raster rainfall data within and around the study area. The resulting raster layer was reclassified into the five classes with natural breaks. The reclassified rainfall was given a value 1 for least rainfall to 5 for highest rainfall. Precipitation criteria are assigned a weight of 3.5 in accordance with literature review and area type (Özkan and Tarhan, 2016). Figure 4.16 and 4.17 shows the results of the raster rainfall layer and the reclassified rainfall data.

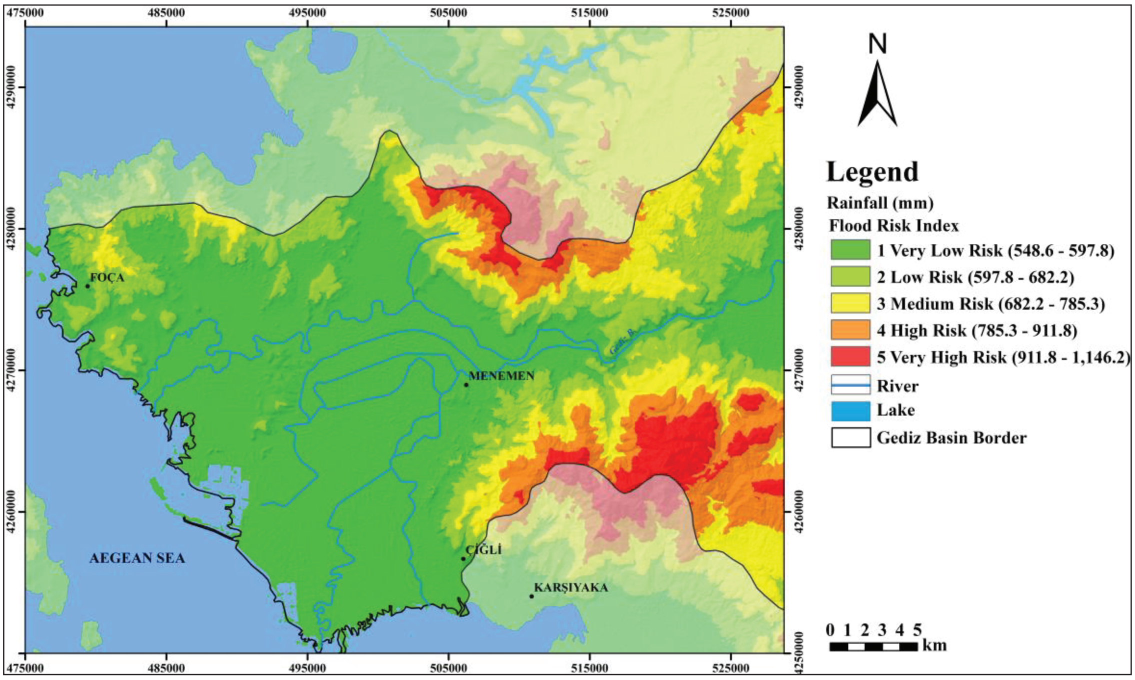


Figure 4.17. Reclassified rainfall map of the study area according to the flood risk index (FRI)

CHAPTER 5

RESULTS AND DISCUSSION

In this section, results of flood risk analysis will be evaluated. In the following process, mitigation and resilience policies will be focused on and the existing environmental plan will be analyzed according to the resultant map (Figure 5.1).

For the determination of the areas under flood risk, the formula used for the 6 criteria decided within the literature research is given below with the weight values.

$$\mathbf{FRA} = \sum_{i=1}^{n} W_i P_i = 3.5*P_{\text{Slope}} + 3.5*P_{\text{Elevation}} + 3.5*P_{\text{Rainfall}} + 4.5*P_{\text{Distance from Rivers}} + 3*P_{\text{Landuse/cover}} + 5*P_{\text{Distance from junction p. of rivers}}$$

Where: FRA → Flood Risk Areas

$n = 6$ → The number of the proxies

P_i → Proxies,

W_i → Weights of proxies, which ranges from 1 to 5.

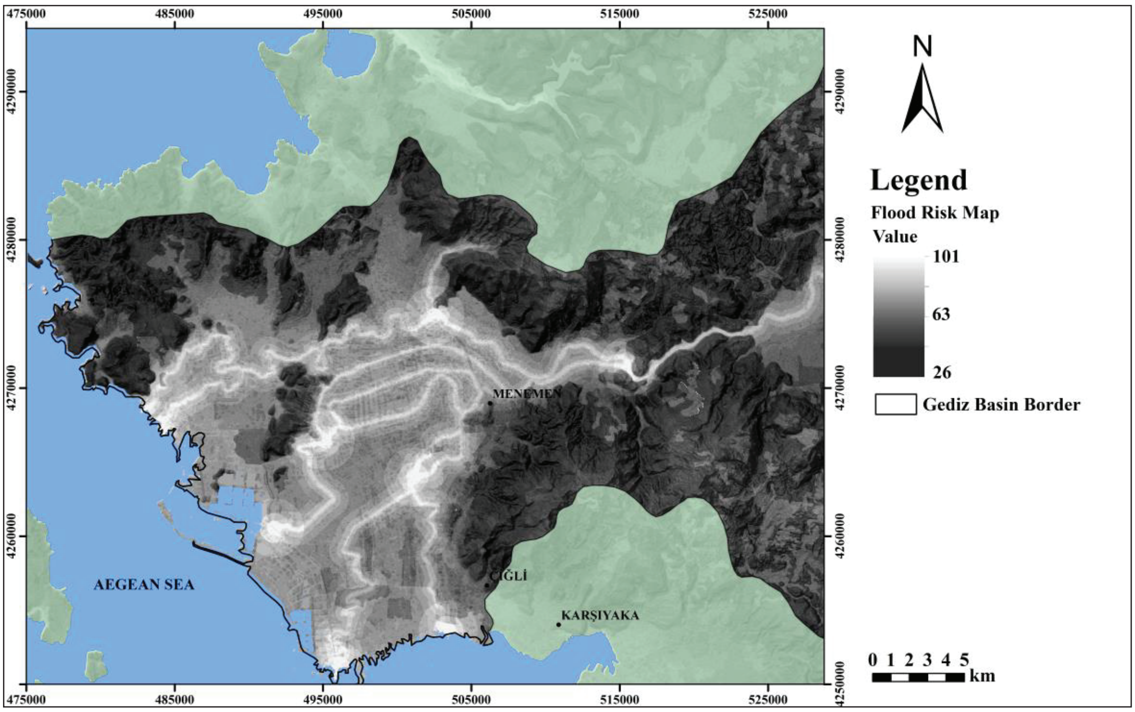


Figure 5.1. Flood risk areas (FRA) in the study area; created from summation of all the six proxy maps

Within the scope of the analysis studies, each criterion is classified by the classification method consisting of 5 classes. Then, according to their importance, weights of proxies were assigned in the previous section. In final step, all the proxies with the weight values were analyzed with the weighted overlay tool of the ArcGIS software. The final summed flood risk map generated within this scope occurred between 26 and 101 pixel values. The lowest pixel value indicates the least risky location, while the highest pixel value shows the most risky location. In order to classify the result map, the pixels were divided by the total number of weights that entered into the equation. Figure 5.1 and 5.2 shows the result map and its classification according to FRI values.

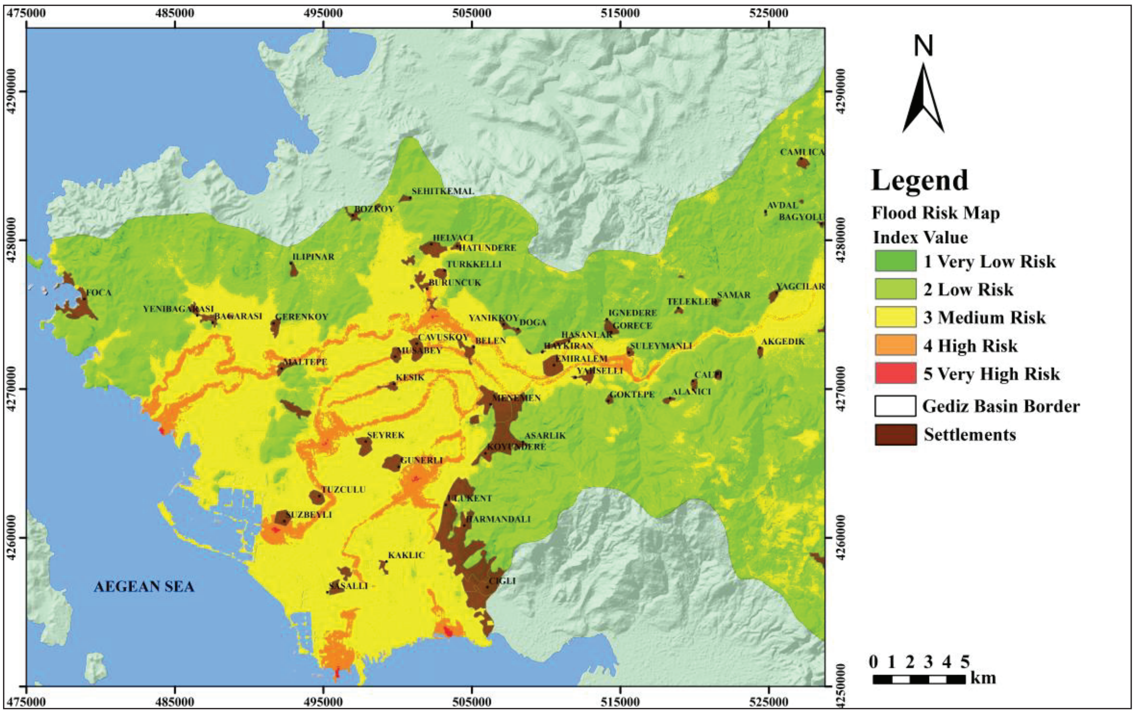


Figure 5.2. Reclassified FRA in the study area according to the flood risk index (FRI) as the final flood risk map

When the result map is examined, it is observed that the areas where high risk is concentrated in the area that close to the rivers. In addition, as mentioned in the literature, the rivers are the starting location of flood and around the river is the most vulnerable areas which is called flood zone (Fernandez and Lutz, 2010). Moreover, the highest risk areas were identified at the junction points of the river with sea level.

As stated in proxy reviews, low slope areas and low elevation areas are likely to be under floods risks due to the water flow (Fernandez and Lutz, 2010). Elevation, slope and land use criteria are most effective in the whole plain, where medium risk is dominant. The most important reason for this the elevation values and slope values of the valley where the agricultural areas are low and it represent high risk. Therefore, these two proxies have a significant impact on the flood risk on agricultural areas. In this direction, the flood risk index values in the region where agricultural areas are concentrated correspond with the literature. Agricultural areas, which formed the majority of the study area, are determined as medium risk areas.

When the settlement areas are examined on the result map; it can be easily observed that Süzbeyli, Kesik, Musabey, Çavuşköy, Belen, Buruncuk and Emiralem are under high flood risk and medium flood risk areas. In addition to this, in mountainous regions, there are a lot of areas where there is low flood risk according to the result map. The regions with very low and very high flood risk were observed very little and the risk distribution (Table 5.1) is as follows:

Table 5.1. Area distribution according to FRI

Flood Risk Index	FRA (km^2)
5 (Very High Risk)	0.8
4 (High Risk)	64.6
3 (Medium Risk)	456.3
2 (Low Risk)	637.3
1 (Very Low Risk)	4.4

As seen in Table 5.1, 637 km^2 of the area is low risk and these areas constitute mountainous regions and forest areas. In addition, high risk and medium risk were determined in the regions where the agricultural areas which are the center of the plain and which do not have forest structure are concentrated. Medium risk level areas have 456 km^2 area which dominates the region after low risk. On the other hand, very high risk areas were determined only 0.8 km^2.

When the result map is matched with the elevation map the areas under flood risk can be seen well in Figure 5.3. As it is seen in the figure, there are medium and high degree risk regions in the area where the plain is located and almost all of the mountainous areas were identified as low flood risk areas.

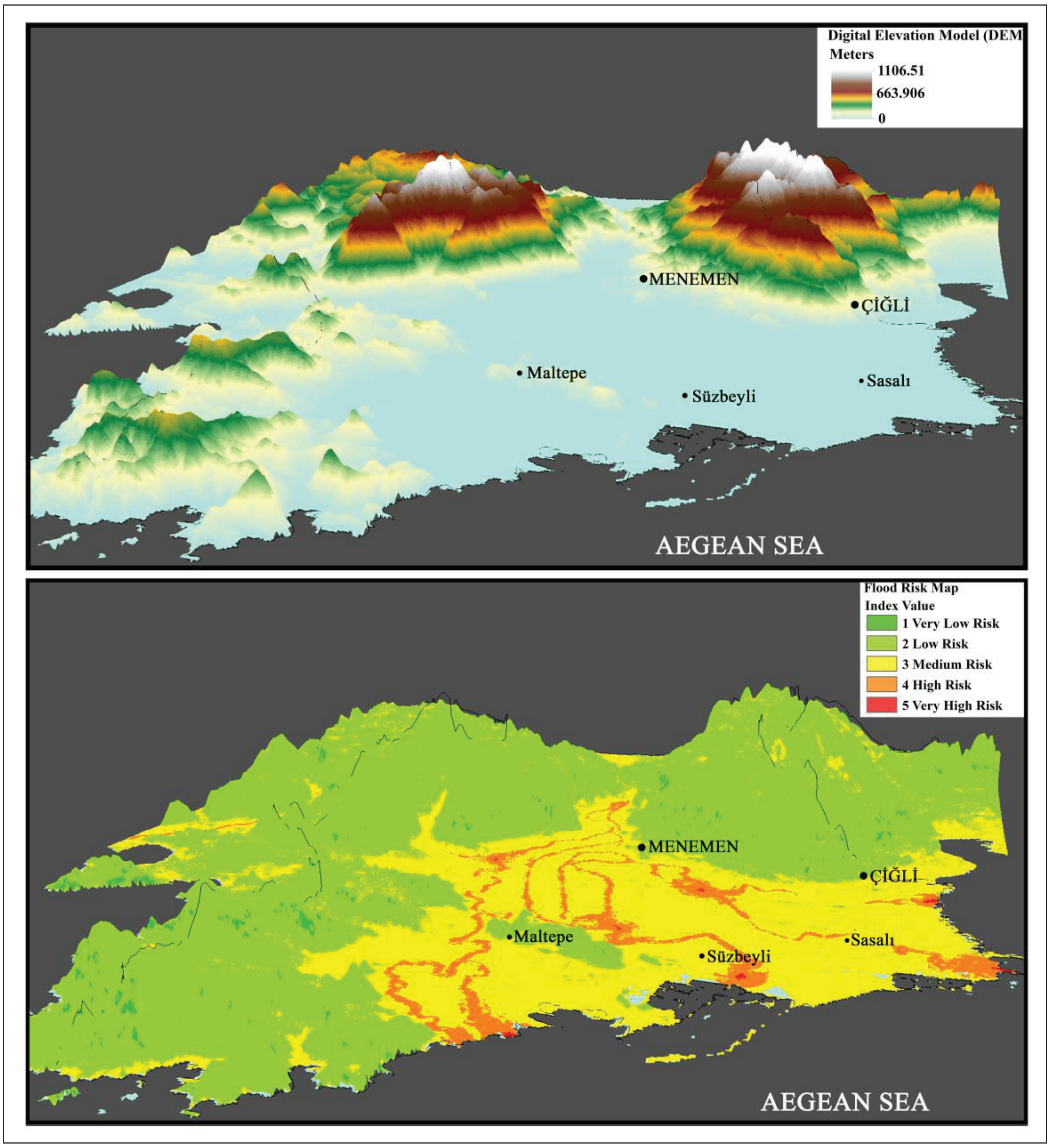


Figure 5.3. 3-D digital elevation model (DEM) and a 3-D model of the flood risk areas (FRA)

5.1 Population Distribution of Settlements under Flood Risk

There are many settlements within the area that are in high risk and medium risk areas (Table 5.2). The population values of the settlements were compared with the approximate risk levels in order to perform sensitivity studies for these areas. During the examination, settlements under medium risk areas and settlements under high flood risk settlements were considered.

Table 5.2. Population distribution of areas under flood risk

Under Medium Flood Risk Settlements	Population	Under High and Medium Flood Risk Settlements	Population
Yenibağarası	2,840	Musabey	294
Tuzçullu	251	Çavuşköy	420
Seyrek	5,893	Belen	230
Günerli	159	Süzbeyli	35
Sasalı	3,736	Buruncuk	462
Kaklıç	1,567	Emiralem	1,209
Yahşelli	4,544	Kesik	757
Süleymanlı	527		

In this context, a total of 19517 people in 8 neighborhoods live under moderate flood risk. On the other hand, a total of 2650 people live in areas of high and medium flood risk in 7 neighborhoods. Settlements, especially those with moderate and high flood risk, are located very close to the river beds. Many variables should be taken into account when determining sensitivity; occupation, demographic structure, location, and wealth (WDO, 2008). In this respect, we have reached a conclusion by linking the population values and the risk values associated with the locality. In this case, considering the rivers, which are the biggest starting point of the flood disaster, measures should be taken for these neighborhoods.

5.2 Flood Risk Management for the Study Area

In order to manage the flood risk, as mentioned in Chapter 3, it is necessary to first assess the flood risk and then identify areas under risk of floods. As a result of the risk assessment and analysis carried out for the study area, especially the rivers and the wetlands where rivers meet with the sea are identified as high risk areas (Rahmati et al., 2015; Samanta et al., 2016). After determining the areas under the risk of floods, next is to take measures and make a flood risk management plan.

In many parts of the world, especially in river cities, generally accepted structural measures on flood measures are taken (Liao, 2012). However, these measures damage the ecosystem and nature in long term (Burby et al. 2000; Smits et al., 2006). Although many alternative methods have emerged such as water management, non-structural mitigation, in many cities, measures are still taken with engineering methods (Birkland et al., 2003; Godschalk, 2003). However, as mentioned in Chapter 3, the flood risk management can only be achieved by an integrated implementation of structural and non-structural measures (Jha et al., 2012). Therefore, there should be a flood risk management plan where structural and non-structural measures are applied in a holistic manner.

However, most of the floods in our country are in areas where only structural measures have been taken. In addition, since only structural measures are taken it is encouraged to spread urban development normally under risk but looks like risk eliminated areas. Figure 3.8 in Chapter 3, shows integrated FRM scheme. In this context, primarily; mitigation, emergency and recovery processes must proceed together. Therefore, to be prepared with structural and non-structural measures, to be able to act with early warning systems and to interfere with the minimum impact. In the last stage, it is aimed to provide opportunities to fast recovery for people and regions that are damaged. This allows the city not only to be protected with catastrophic policies, but also to be able to cope with a disaster (Serra-Llobet, 2018).

Considering the flood management plan for the study area; risky regions that especially around river areas shows that structural measures for river beds can be effective. In this context, Gediz River Basin Management Plan includes some floodplain that determined by SWW and structural measures. However, as previously mentioned, structural measures must be implemented together with non-structural measures and in basin management plan there are no mitigation strategies for the study area, only some part of the Gediz Basin has structural management plan.

Accordingly, some of the structural and non-structural measures to be taken for the study area can be listed as follows;

- In areas where high risk areas are expanding, water collection areas need to be constructed to reduce the flow rate of water and reduce the risk of flooding in the river zones.
- Floodplain should be defined by making levees around the rivers because low elevation and low slope values expand the floodplain.
- Due to high slope and elevation flows, terracing measures should be carried out in areas where the flow of the Gediz River is affected.

- Early warning systems should be established in neighborhoods with high-middle and middle flood risk and regular preparations should be made against disaster.
- By taking planning decisions and land use control, flood risk should be minimized for residential areas.
- Safe areas should be determined by applying the land use principles. In addition, financial means should be provided to prevent informal buildings that are at risk for low-income citizens.
- To cope with climate change and global warming, natural areas and resources should be protected and sustainable urban development should be implemented by urban planning.
- Informative meetings should be organized in order to raise awareness, and information should be given to reduce risk in education facilities and non-governmental organizations.
- Administrative buildings, hospitals, fire station, etc., to provide assistance and services to people in the event of a disaster should be located where flood risk is the lowest (Making Cities Resilient, 2016).

In order to convert the study area into a resilience zone, the mitigation, emergency and recovery stages must be applied in a holistic manner. As mentioned, the measures taken cannot eliminate the flood risk completely. The impacts of disasters are changing day by day due to global climate change. Therefore, cities should not rely on mitigation measures and should consider policies based on resilience in case of disaster impact.

5.2.1 Flood Risk Map and 1/25.000-Scaled Environmental Plan Examination

The Environmental plan of the study area was investigated in Figure 4.4, Chapter 4. Besides, according to the analysis of study area flood risk maps are evaluated. In the scope of the thesis, two visuals are overlapped in order to evaluate the flood risk maps for 1/25.000-scaled plan.

When the 1/25.000-scaled environmental plan and flood risk map are examined;

- The new residential development areas were offered under the high and medium flood risk with plan's decision.

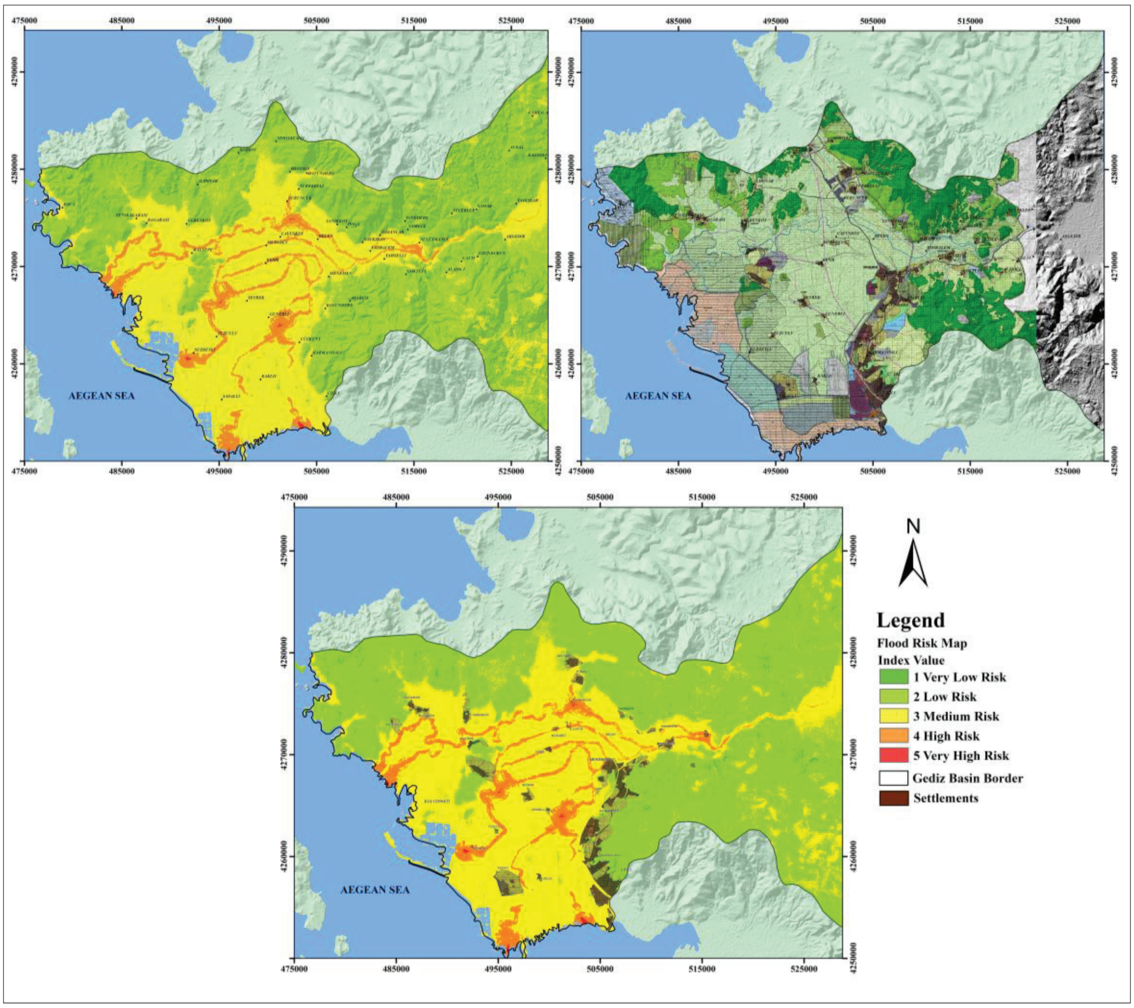


Figure 5.4. Flood risk map and environmental plan of the study area

- The agricultural areas in environmental plan are mostly under high-medium flood risk.
- The determined settlements according to plan where located near the rivers' beds are under high risk.
- The existing settlements and new development areas determined by plan where located in wetland buffer zone are under high and medium flood risks.

In this context,

- Re-examination of housing development areas for settlements under risk of floods,
- Moving the settlements which are located close to the rivers' beds into safe areas and turning these areas into recreational areas,

- Reorganization of the locations of the settlements within the wetland buffer zone that hit high risk areas,
- The Gediz River flood boundaries determined in line with the plan decision should be revised,

are the a few significant measures should be taken and transfer to plan to minimize vulnerability.

5.2.2 Partnership for Flood Risk Management

The decisions taken in the flood planning should be applied from the top to the bottom. Because the creation of social awareness, the inclusion of academic institutes, public institutions and private organizations in flood planning is an important process for minimizing the vulnerability (Figure 5.5).

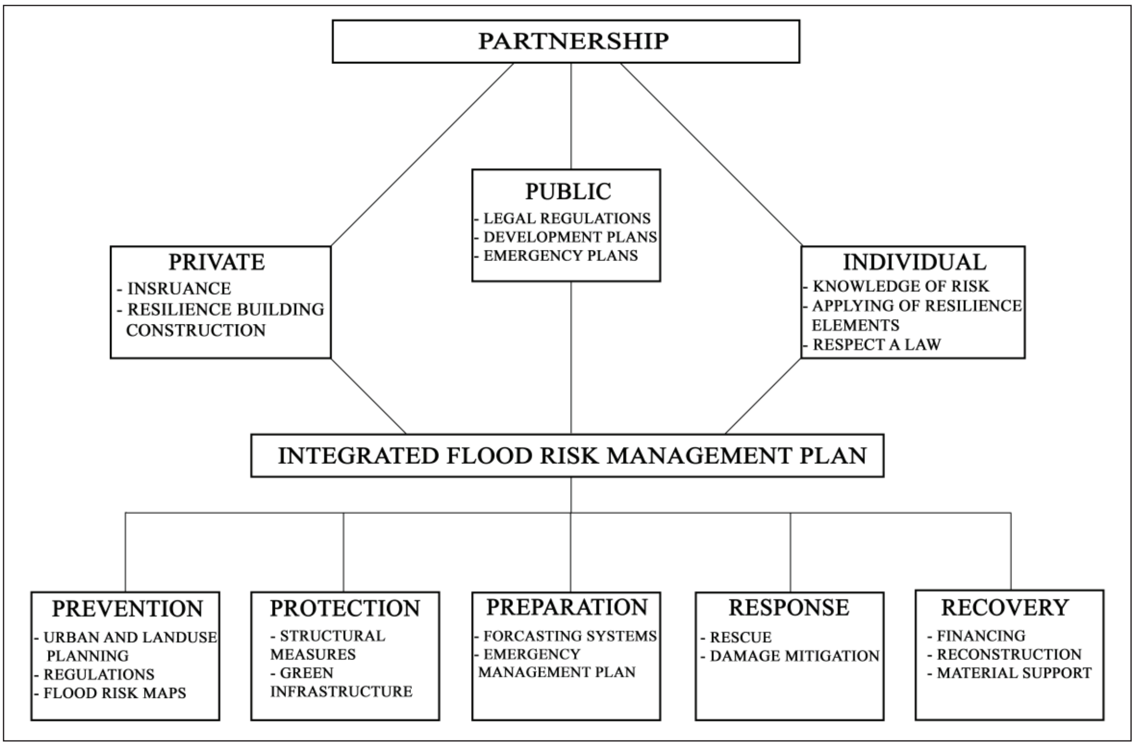


Figure 5.5. Partnership of integrated flood risk management plan

Besides, by integrating different perspectives together, faster and more effective interventions can be made in areas at risk of flooding (Tingsanchali, 2012). Therefore, partnerships and integrated flood risk management scheme are drawn with literature research (Tingsanchali, 2012, Serra-Llobet, 2018).

CHAPTER 6

CONCLUSION

Worldwide; unplanned development, global climate changes, and rapid population growth cause increase in natural disasters. The frequency of the flood, which is the most common disaster and causes the most significant damages, also has increased remarkably in the last three decades. Moreover, the geographical structure of Turkey; has a high potential for floods due to its topography, meteorological and hydrological factors. For this purpose, the Menemen Plain and its surroundings where the Gediz Basin was poured into the Aegean Sea was evaluated. Furthermore, the area around the Menemen Plain is surrounded by high mountains, the high agricultural quality in the plain, the elevation of 10 m above sea level, and the low water holding capacity of the soil structure have been found worthwhile. In this direction, the study aims to determine the areas under flood risk and to take measures to reduce the risk. To this end, six criteria have been identified to be evaluated in the GIS program for study area examination; (1) Slope, (2) Elevation, (3) Distance from Rivers, (4) Distance from Junction Points of Rivers, (5) Land Use/Cover (LULC), and (6) Rainfall. According to their effects on flood disaster, criteria weight was assigned also were evaluated by the weighted overlay method in a GIS environment. The resultant map which was classified into five classes as the flood risk index (FRI); (1) very low, (2) low, (3) medium, (4) high, and (5) very high flood risk were created. In this context, the study was found as the junction points of rivers on the plain are under very high risk (0.8 km^2) the settlements close to the riverbeds (64.6 km^2) are under high risk, wetlands and the majority of the plain (456.3 km^2) are under medium risk, while the mountainous areas surrounding the area are under low risk (637.3 km^2) and very low risk (4.4 km^2). According to the resultant flood risk map, the highest risky flood locations with more population were seen as settlements of Emiralem, Kesik, Buruncuk and Çavuşköy in order. On the other hand, medium flood risk settlements with more population were found as Seyrek, Yahşelli, Sasalı and Yenibağarası in order.

Following this result, structural and non-structural measures; river environments conversion into public spaces; re-location selection for sites under risk; establishment of early warning systems; taking planning decisions to the protection of natural areas and development to safe zones, are a few determined strategies to minimize flood risk for these settlements. In addition, as a result of the 1/25.000-scaled plan evaluation, the plan decisions for the areas at risk were developed. For this mitigation policies, public, private and individuals need to manage this process with a participatory policy for an integrated flood risk management plan.

Therefore, the GIS software, weighted overlay analysis, and the six determined criteria were efficient in the determination of flood risk areas. For this reason, the use of the criteria defined in the thesis especially in river cities will achieve efficient results. Also, the implementation of structural and non-structural measures implemented around the world with individual and private company participation, rather than just public, will reduce the risk of flooding and eliminate the vulnerability.

Consequently, for further studies, mapping the areas under flood risk and taking mitigation policies, integrating these maps with urban planning at every level are the essential stages to cope with the flood disaster. Especially for decision makers, flood risk maps can provide location preferences for safe urban development, and agricultural development areas. In addition, integration of flood risk maps with urban planning can provide adaptive development against climatic changing rather than staying resistance against it. In addition, for integrated flood risk management, connecting with all people at every level of risk is a key to accomplish because it increases concordance and reduce conflict. This should be unified with decisive leadership from bottom to top from local to national and from private to public. Therefore, integrated flood risk study with partnership for building safe and resilience environment can success.

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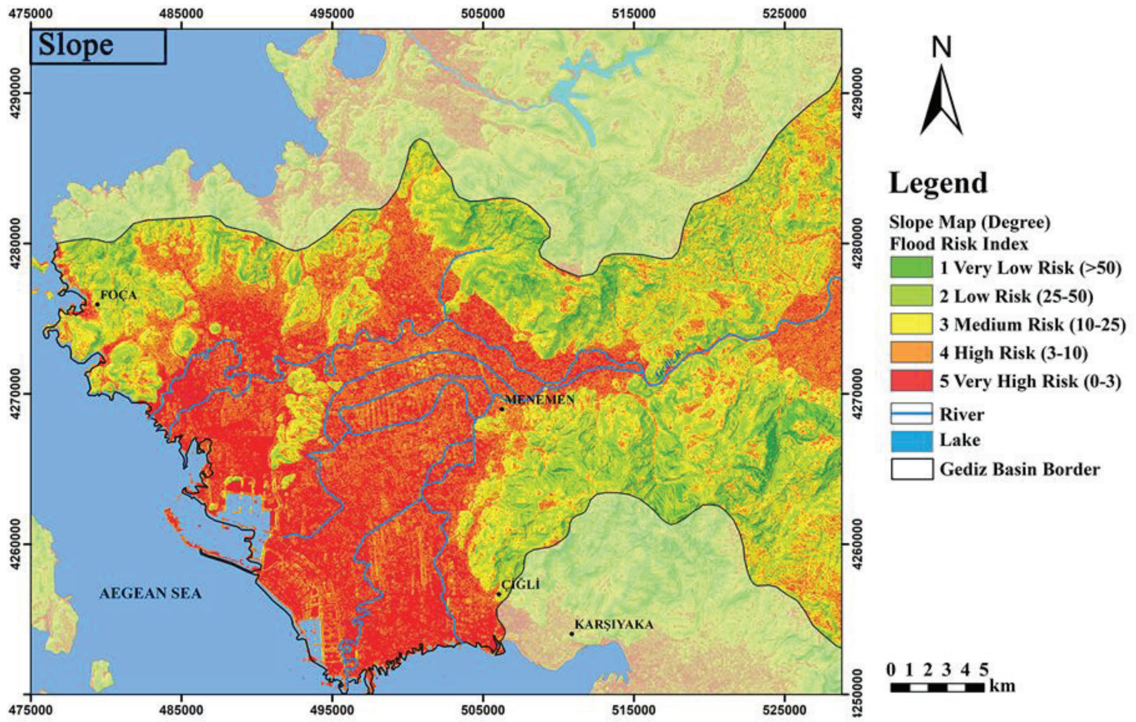
APPENDIX A

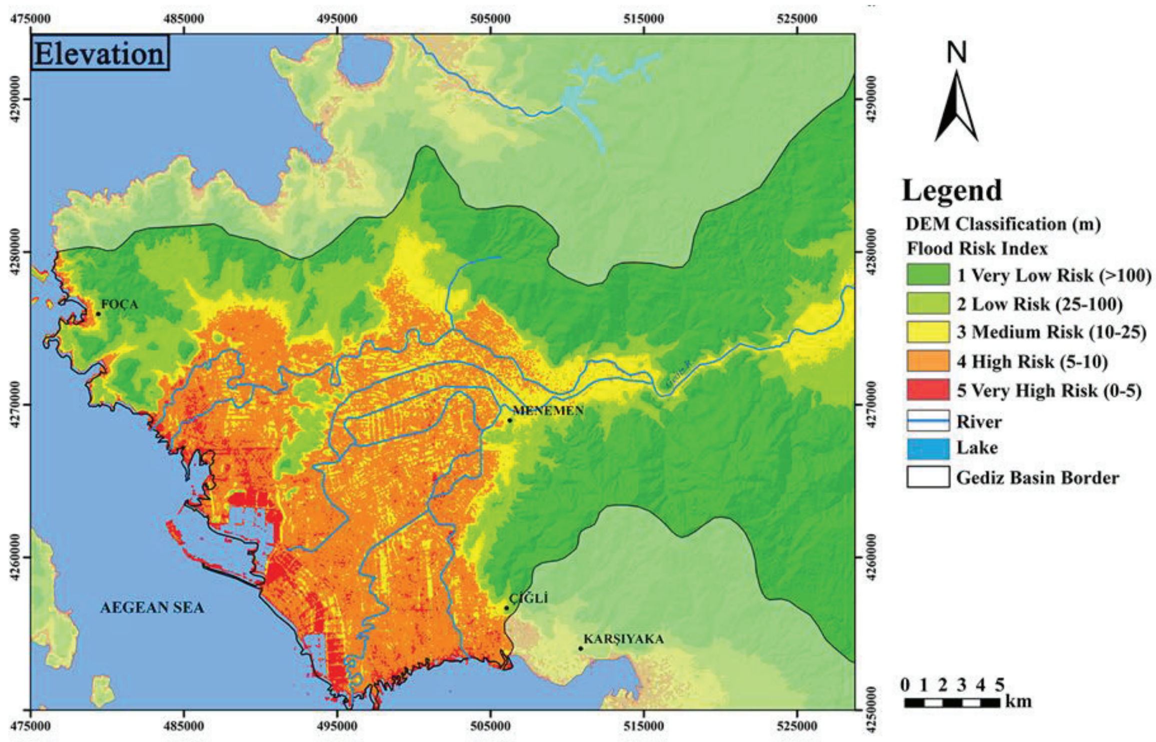
ALL PROXY CLASSES AND WEIGHTS

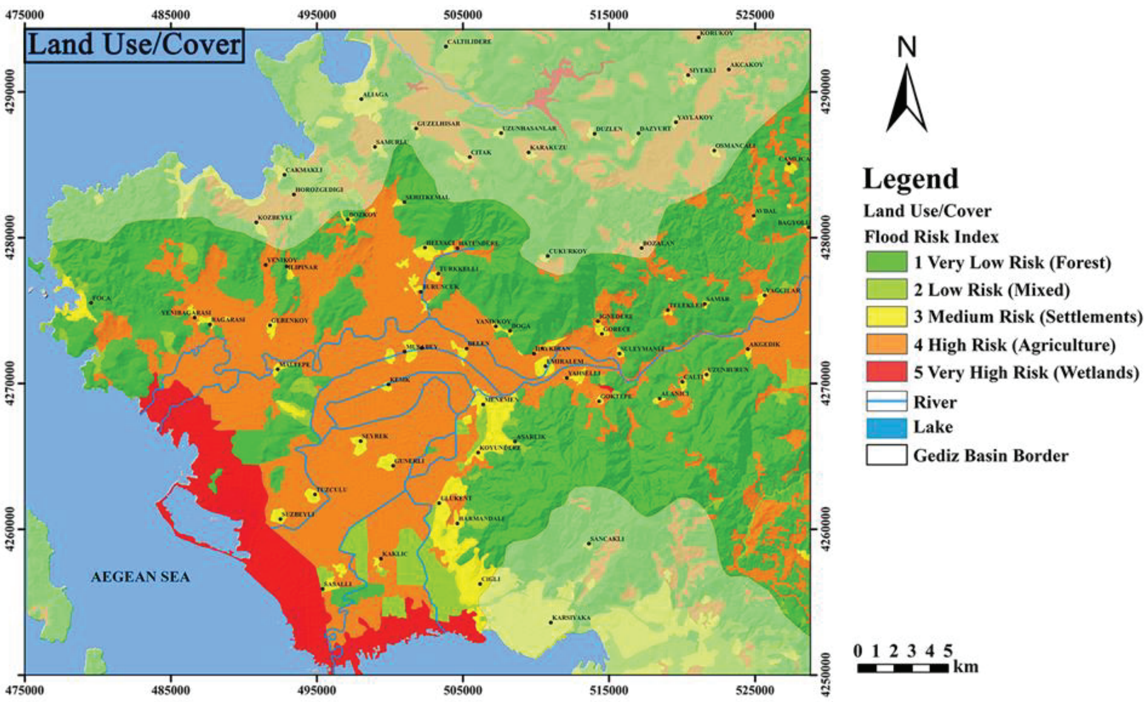
	Proxies	Intervals	Descriptive Level	FRI Value	Weight	Data Processing Methods
1	Slope (degree)	0-3 3-10 10-25 25-50 >50	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	3.5	ArcGIS Software 10.2 Slope Tool Slope Classification
2	Elevation (meters)	0-5 5-10 10-25 25-100 >100	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	3.5	ArcGIS Software 10.2 DEM Classification
3	Distance from Rivers (meters)	0-100 100-200 200-500 500-1000 >1000	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	4.5	ArcGIS Software 10.2 Euclidean Distance Tool
4	Distance from Junction Points of Rivers (meters)	0-250 250-500 500-1000 1000-2000 >2000	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	5	ArcGIS Software 10.2 Euclidean Distance Tool
5	Landuse /Cover	Wetlands Agriculture Settlements Mixed Forest	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	3	Corine Land Use/Cover and Updating data with Google Satellite Image
6	Rainfall (mm)	911.8-1146.2 785.3-911.8 682.2-785.3 597.8-682.2 548.6-597.8	Very High Risk High Risk Medium Risk Low Risk Very Low Risk	5 4 3 2 1	3.5	Schreiber Calcuation Method and ArcGIS Software 10.2 Natural Neigbor Interpolation

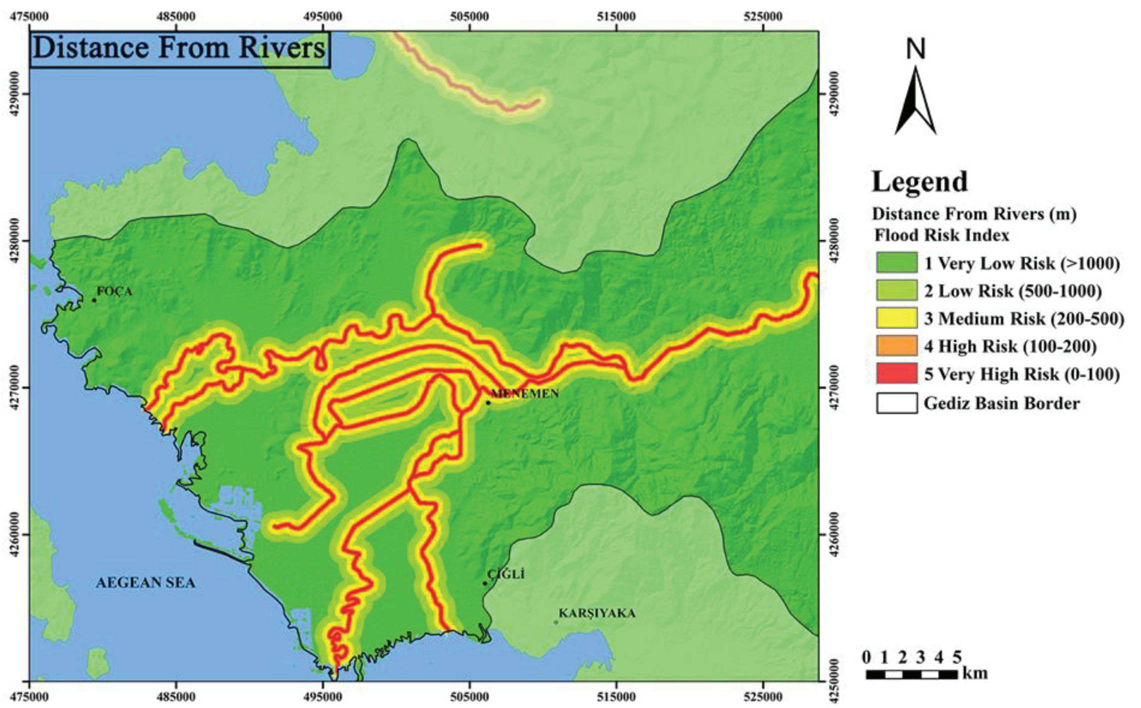
APPENDIX B

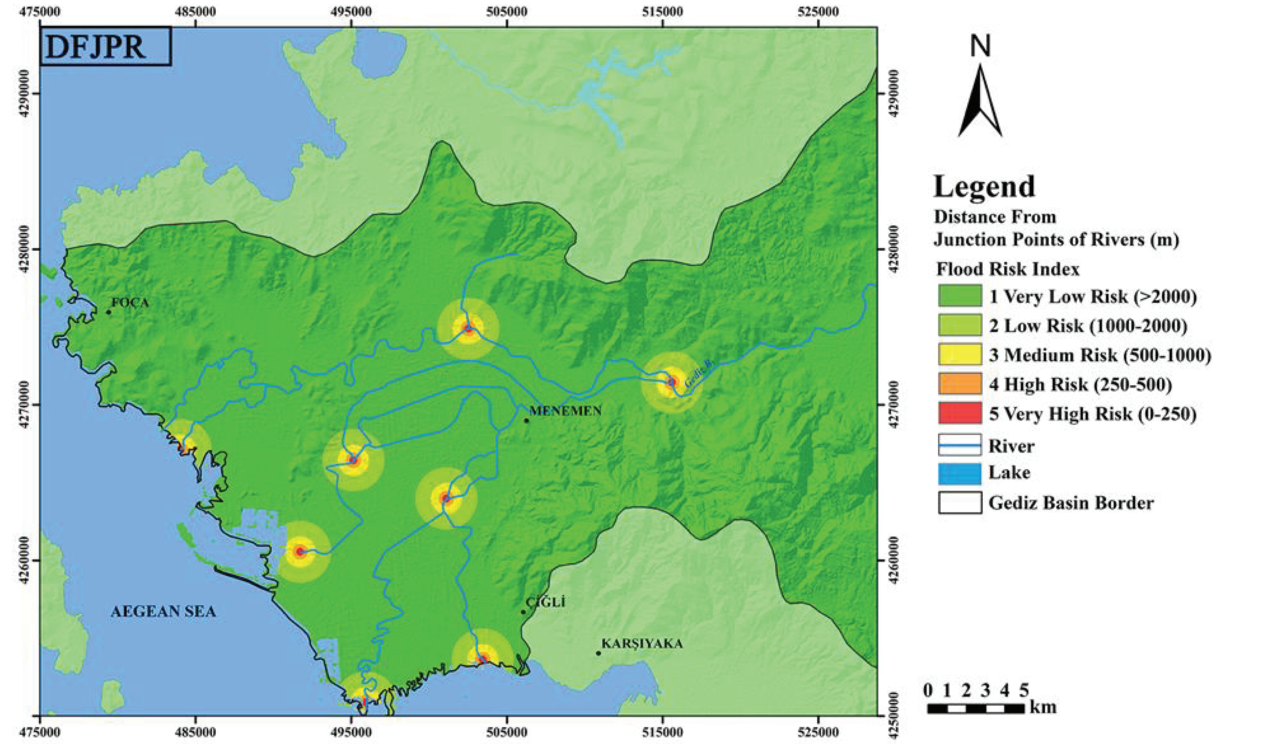
ALL PROXIES AND FINAL MAP

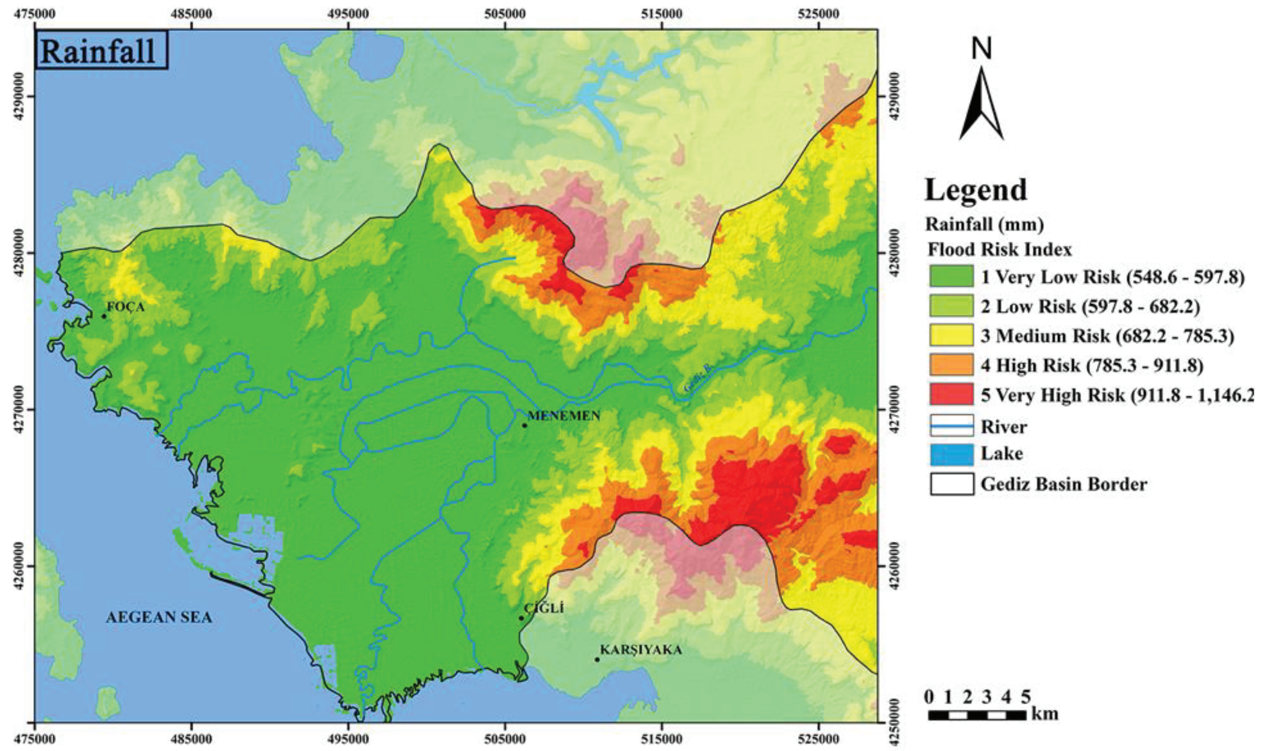


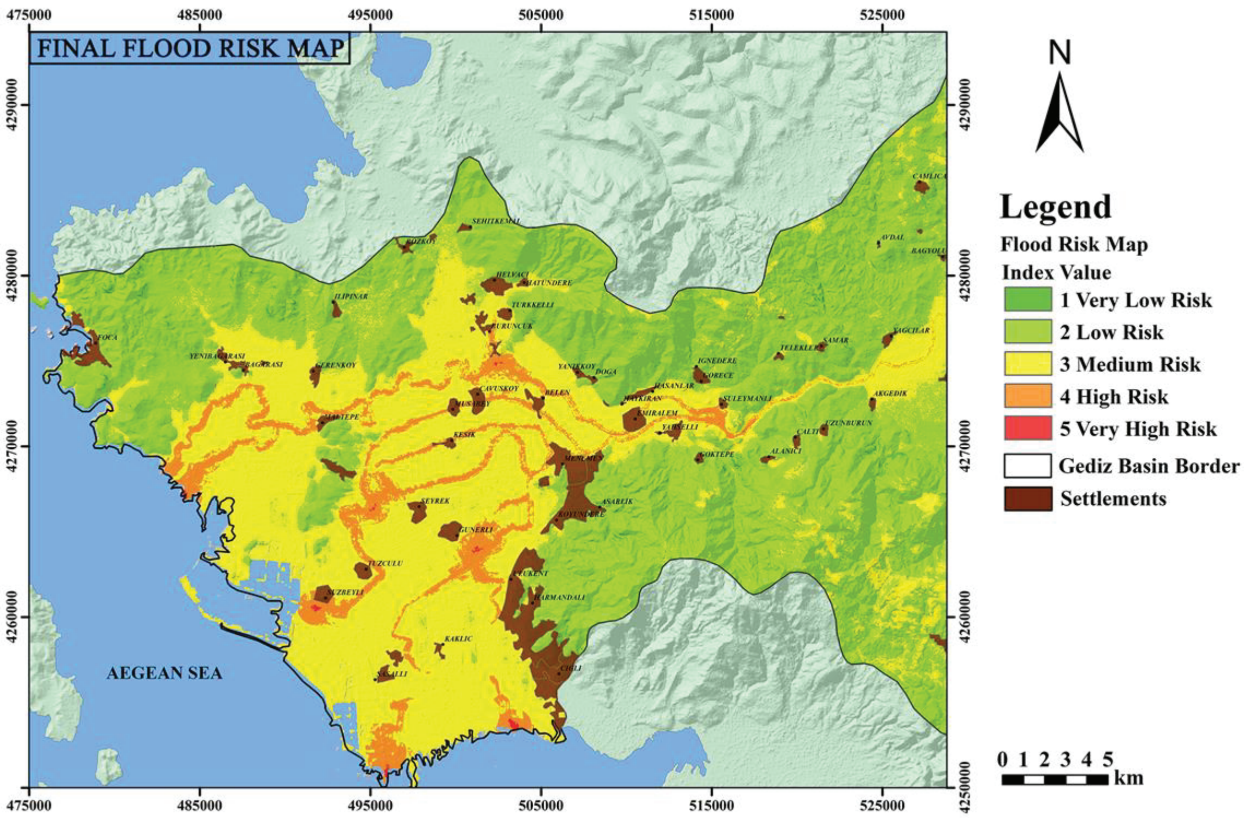



Land Use/Cover
475000
485000
495000
505000
515000
525000
4290000
4280000
4270000
4260000
4250000
AEGEAN SEA
N
Legend
Land Use/Cover
Flood Risk Index
1 Very Low Risk (Forest)
2 Low Risk (Mixed)
3 Medium Risk (Settlements)
4 High Risk (Agriculture)
5 Very High Risk (Wetlands)
River
Lake
Gediz Basin Border
0 1 2 3 4 5
km


Distance From Rivers
475000
485000
495000
505000
515000
525000
4290000
4280000
4270000
4260000
4250000
FOÇA
MENEMEN
ÇİGLİ
KARŞIYAKA
AEGEAN SEA
N
Legend
Distance From Rivers (m)
Flood Risk Index
1 Very Low Risk (>1000)
2 Low Risk (500-1000)
3 Medium Risk (200-500)
4 High Risk (100-200)
5 Very High Risk (0-100)
Gediz Basin Border
0 1 2 3 4 5
km


DFJPR
475000
485000
495000
505000
515000
525000
4290000
4280000
4270000
4260000
4250000
FOÇA
MENEMEN
ÇİGLİ
KARŞIYAKA
AEGEAN SEA
N
Legend
Distance From
Junction Points of Rivers (m)
Flood Risk Index
1 Very Low Risk (>2000)
2 Low Risk (1000-2000)
3 Medium Risk (500-1000)
4 High Risk (250-500)
5 Very High Risk (0-250)
River
Lake
Gediz Basin Border
0 1 2 3 4 5
km


Rainfall
475000
485000
495000
505000
515000
525000
4290000
4280000
4270000
4260000
4250000
FOÇA
MENEMEN
ÇİGLİ
KARŞIYAKA
AEGEAN SEA
N
Legend
Rainfall (mm)
Flood Risk Index
1 Very Low Risk (548.6 - 597.8)
2 Low Risk (597.8 - 682.2)
3 Medium Risk (682.2 - 785.3)
4 High Risk (785.3 - 911.8)
5 Very High Risk (911.8 - 1,146.2
River
Lake
Gediz Basin Border
0 1 2 3 4 5
km


FINAL FLOOD RISK MAP
475000
485000
495000
505000
515000
525000
4290000
4280000
4270000
4260000
4250000
AEGEAN SEA
N
Legend
Flood Risk Map
Index Value
1 Very Low Risk
2 Low Risk
3 Medium Risk
4 High Risk
5 Very High Risk
Gediz Basin Border
Settlements
0 1 2 3 4 5
km