

Creation Of Flood Hazard Map On Gis Base And Examination Of Property Status In Flooded Areas

Gül USLU¹ and Faik Ahmet SESLİ^{2}*

Authors' affiliations and addresses:

¹Department of Occupational Safety and Health,
Faculty of Health Sciences, Sinop University,
57000, Sinop, Turkey
e-mail: guslu@sinop.edu.tr

²Ondokuz Mayıs University, Geomatics
Engineering, Samsun, Turkey
e-mail: fasesli@omu.edu.tr

***Correspondence:**

Faik Ahmet Sesli, Ondokuz Mayıs University,
Geomatics Engineering, Samsun, Turkey
tel.: +905352084484
e-mail: fasesli@omu.edu.tr

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Abstract

Floods are among the most damaging natural events after earthquakes. However, human activities, such as altering riverbeds, increasing riverside construction, or altering river directions, exacerbate flood risks. Flood risk maps are created based on flood recurrence data to assess potential damage.

In this study, the Mert River and Yılanlıdere were chosen as the study area because they caused significant loss of life and property during the flood that occurred in the Mert and Yılanlıdere Rivers in Samsun. To establish the flood hazard map of the study area, Samsun Metropolitan Municipality has sixty-five 1:1000 current maps and two 1:5000 zoning maps, and annual flood repetition frequencies of 10, 25, 50, 100, 500, and 1000 years have been provided. The obtained data was then used to generate a flood hazard map based on the flood recurrence data provided in the Geographic Information System environment using the Hec-GeoRAS and HEC-RAS programs. According to the obtained flood hazard maps, the size of the flood area, the number of buildings and parcels within this area, the number of independent sections in the buildings, and the number of people in those places were determined before and after the flood reclamation work was completed in 2014 on a neighborhood basis.

As a result, this study proposes whether the breeding work conducted is sufficient, whether flood insurance applies in my country, and which structures are located in the flood area.

Keywords

Flood, Flood Hazard Map, Geographic Information System, Reclamation



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Introduction

Natural or human activity-induced events that cause the interruption of general life and human activities for a certain period, creating losses of lives, economic losses, and social losses for people, are defined as "disasters" (TAMP, 2013). Many countries are exposed to meteorological natural disasters that result in significant loss of life and property from time to time, depending on their geography, climatic conditions, and geological and topographic characteristics. Flood, one of these natural disasters, is defined as an event in which streams overflow their beds for various reasons, creating a flow size that interrupts normal socioeconomic activity in the impacted area by damaging surrounding lands, settlements, infrastructure facilities, and wildlife. River flooding is common in many parts of the world after excessive local rainfall or mass snowmelt. Events that affect floods include rapidly developing rainfall, slow and low-intensity rainfalls, snowmelt, the destruction of dams or dikes, or a combination thereof, as well as events such as earthquakes, landslides, tides, and storm waves. In general, floodwaters reach the sea through the natural bend of the stream and the normal floodplain. However, with developing urbanization, the natural stream bed is narrowed by bridge piers, transportation, pipelines, sewer drains, and other obstacles. Although the flood is a natural phenomenon that develops in response to the region's climatic conditions and topographic characteristics, flood damage often occurs entirely as a result of human activities.

It has been observed that climate change significantly exacerbates flood events and their effects on people. According to EM-DAT (Emergency Events Database) data, 3,515 flood events were recorded between 2000 and 2021. 28 of these took place in Turkey. On a continental basis, in 21 years, 836 flood events occurred in Africa, 732 in America, 1426 in Asia, 430 in Europe, and 87 in the Pacific Ocean (Fig. 1) (EM-DAT, 2021).

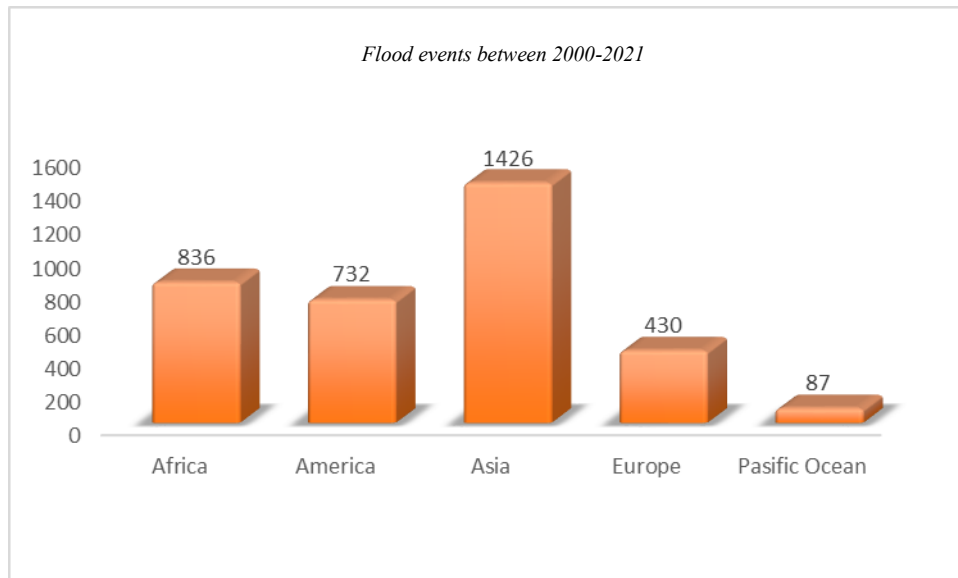


Fig. 1. Number of Floods in the World in 2000-2021

Uncontrolled urbanization, due to the failure to identify endangered areas and take necessary precautions, is the leading cause of floods worldwide. In Turkey, floods are the natural disasters that cause the most economic loss after earthquakes (Akay et al., 2010). Floods can be classified into four categories based on meteorological factors, location of occurrence, causes, and duration (Fig. 2). From a meteorological perspective, floods are divided into five groups: winter rain floods, summer convective storm floods, snowmelt floods, residential floods, and sea wave and tidal floods. Based on location, they are categorized into five groups: stream and river floods, mountainous area floods, urban floods, coastal floods, and dam floods. In terms of cause, floods are categorized into two types: those resulting from natural causes and those caused by human intervention. Finally, in terms of duration, floods are classified as slow-developing floods, fast-developing floods, and sudden floods.

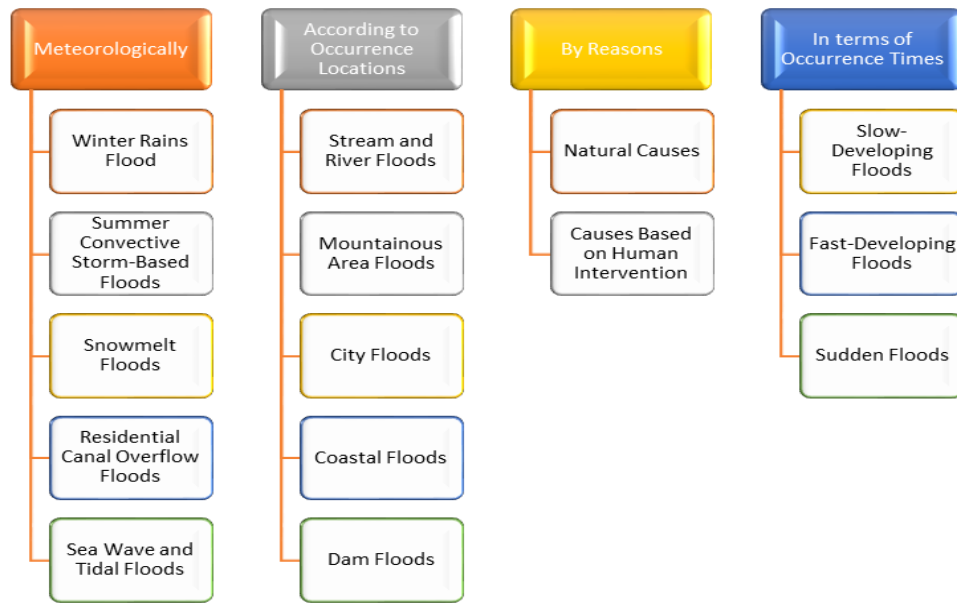


Fig. 2. Urban Impact of Flood (Çetin and Tezer, 2013)

In this study, a flood hazard map was created using data obtained from Samsun Metropolitan Municipality and the 7th Regional Directorate of State Hydraulic Works (DSI), along with metadata and other data generated in the GIS (Geographical Information System) environment, both before and after the flood reclamation work was carried out. Then, the land and buildings that fell within the flood hazard area were identified, and the ownership status of the areas that could be affected by the flood, as well as the number of people residing in these areas, was examined.

While it takes a considerable amount of time to create a flood hazard map using traditional techniques, advancements in technology have enabled the creation of flood hazard maps that predict areas likely to be affected by floods with great accuracy and speed, utilizing remote sensing techniques and geographic information systems.

Many scientific studies have been conducted on this subject. Early studies on this subject demonstrated that remote sensing data can serve as a foundation for small- to medium-sized maps (Byrne et al., 1980). In 1987, Imhof et al. mapped the Lower Ganges River flood boundaries using L-band radar data with a Landsat-Multispectral Scanner (MSS) to create a flood hazard map using satellite imagery, which was a new concept in the late 1980s. In the 1990s, the HEC-RAS (Hydraulic Engineering Center, River Analysis System, 1998) program, running under the Windows operating system, was developed by the American Hydraulic Engineering Center to model rivers or open channel structures. Yazıcılar and Önder (1998) utilized the HEC-RAS program to calculate the areas that may occur during floods in the Bartın River in Turkey, and very close results were found between the actual areas that occurred during the flood and the areas mapped in the program.

Smemoe et al. (2003), using the HEC-RAS model to determine the boundaries of flood-hazardous areas, stated that the flood map they created with the data taken from the model will provide benefits in many areas, from making arrangements in the settlement plans to flood insurance.

Ekinci (2003) considered the maximum hydrological data that formed the flood and the source of the water to examine the floods that occurred in the Black Sea Region in the past. In this study, rainfall and hydrological parameters of the İhsaniye Creek Basin were developed, and rainfall and flow characteristics, as well as flood recurrence frequency estimation, were investigated.

Adams et al. (2006) prepared the USACE HEC-RAS model for the Ohio River basin. This model takes into account the tributaries joining the mainstream and the effects of dams, bridges, etc. on it, and even the calculation of flows caused by rainfall. At the end of the study, it was stated that the modeling data quality is important, and better results are obtained with high-quality data.

Created flood vulnerability mapping for predicted flood areas in the Kelantan river in Malaysia using a logistic regression model and GIS (Pradhan 2009). In the study, it has been shown that a very rapid assessment can be made about the flood-affected area in the system developed by using the RADARSAT data, which is not particularly affected by the clouds, information about the land use that was flooded during the flood can be revealed immediately and the number of people whom the flood may damage can be determined in a very short time.

In their study, Brivio et al. (2010) determined the estimated flood area when the flood was most intense by combining the flood areas from DEM data and SAR (synthetic aperture radar) images obtained by the GIS technique, considering the flood that occurred in the Piemonte region of Italy in November 1994.

Jing and Chuan (2010), using Quikbird satellite image, elevation model, and GIS data, stated that the problems occurred in the infrastructure in flood-affected areas and that damage assessment studies provided accurate and fast results for the flood that occurred in Wenshan, China, on July 26, 1998.

Bayazit et al. (2014) created flood hazard maps for the Porsuk Stream. UA and GIS methods were used in the study. The obtained data were analyzed, and the necessary geometric data were transferred to the HEC-RAS software. Hydraulic data were then entered and analyzed for 50, 100, and 1000-year flood flows. According to the obtained results, it was determined that some neighborhoods in Eskişehir province were under flood hazard due to the river passing through the area.

Geyikli (2015) conducted the flood analysis study of Derme Creek in his thesis. In the study, flood levels were determined using ArcGIS and HEC-RAS programs, which incorporated measurements taken in the field and digitized maps. Some recommendations were given by interpreting the obtained flood levels.

The study by Parsian et al. (2021) presents a simple flood hazard assessment method using remote sensing data and GIS in Western Iran. Various datasets were generated, including DEM, precipitation, river proximity, TWI, LULC, soil type, NDVI, and erosion rate. These datasets were converted into fuzzy values, and the Analytical Hierarchy Process (AHP) was used to assign weights to each dataset. The weighted fuzzy values were then integrated through fuzzy analysis to produce a flood hazard map with five risk levels.

In a study conducted by Maranzoni et al. (2022), probabilistic methods are widely used to assess residual flood risk in levee-protected floodplains. These methods can account for uncertainty sources such as breach location and flood event characteristics, and quantitatively evaluate the confidence level of the results. However, the possibility of multiple breaches during the same flood event is often overlooked. This study proposes a probabilistic method that includes multiple breach scenarios and conducts flood simulations using 1D-2D hydrodynamic modeling. The results are presented through statistical maps showing flood hazard and uncertainty levels. The method was applied to the middle reach of the Po River in Italy, revealing that multiple breach scenarios significantly increase uncertainty in flood hazard predictions.

Vashist (2024) integrated the Analytical Hierarchy Process (AHP), a multi-criteria decision-making method, with the Geographic Information System (GIS) to create flood hazard maps for the Krishna River basin. These maps were classified into three different hazard levels using thematic layers derived from nine hazard indicators and the weighted overlay method. The results obtained were verified by comparing them with the field data of the region, and the reliability of the method was demonstrated.

Zelenakova et al. (2024) assessed flash flood risk in the Topla River basin (Slovakia) based on morphometric characteristics. Using ArcGIS, key morphological indicators were evaluated across sub-basins, and a susceptibility scale was developed from literature, empirical data, and expert judgment. The resulting risk map identifies areas likely to experience adverse impacts from flash floods or hydrological droughts.

Nandam and Patel (2025) developed a framework for flood risk mapping by quantifying flood vulnerability based on indicators. Twelve indicators, categorized into physical, socioeconomic, and environmental components, were evaluated using the AHP-TOPSIS method, which proved to be more robust against rank reversal issues. A semi-2D hydrodynamic model was employed to estimate flood depth, velocity, and momentum for return periods of 50, 100, and 250 years. Flood risk was mapped using a bivariate choropleth scheme that effectively distinguished between hazard and vulnerability. Adaptive capacity was also mapped based on various socioeconomic indicators. The study found that high-risk areas increased due to changes in land use and rising flood magnitudes. Although high adaptive capacity helped reduce the risk of loss of life, infrastructure and economic damages remained.

This paper aims to identify risk areas likely to be affected by floods using Geographic Information Systems (GIS) and remote sensing methods, and to develop flood scenarios and hazard maps. Additionally, it seeks to estimate the potential damage that possible floods could cause to structures and agricultural lands in the region before such events occur, with the resulting findings guiding zoning plans and construction practices. Unlike other studies in the literature, this research also evaluates the adequacy of post-flood protection measures, identifies real estate such as land and housing that may be impacted by future floods, and estimates the number of people who may be affected in these areas.

Materials and Methods

Effects of Floods on Human Life

Floods affect human life in various ways and have a significant impact. Floods have complex effects. Some damages may occur in various dimensions, such as residences, industries, production places, public services, rural areas, transportation roads, and within a river basin (IMO, 2010). It is known that the effects of floods on

health especially occur at the time of the flood (death and injuries, etc.), in the near period after the flood, or the following years (diseases, etc.) (McMichael et al., 2001).

Direct effects of floods on human health: -River flow rate, topographical terrain features, sudden onset of the flood, flood depth, landslides, risk behavior, rock fragments carried by fast-flowing water and fallen trees, contact with drinking water, contact with polluted water, and an increase in physical and emotional stress.

Indirect effects of floods on human health: Damage to water distribution systems, sewage systems, an insufficient supply of drinking water, insufficient water for cleaning, deterioration of the transport system, damage to underground pipes, displacement of storage tanks, leakage from toxic waste areas, the release of chemicals, damage to gas tanks that can cause fire, heavy rainfall, increased proportion of vector habitat, rodent invasion, social disconnection, loss of work, family and friends, cleanup activities following floods, destruction of primary food crops, damage to health services (Menne et al., 1999).

Urban Effects of Floods

We can explain the effects of floods on cities in three stages: physical, social, and economic (Fig. 3).

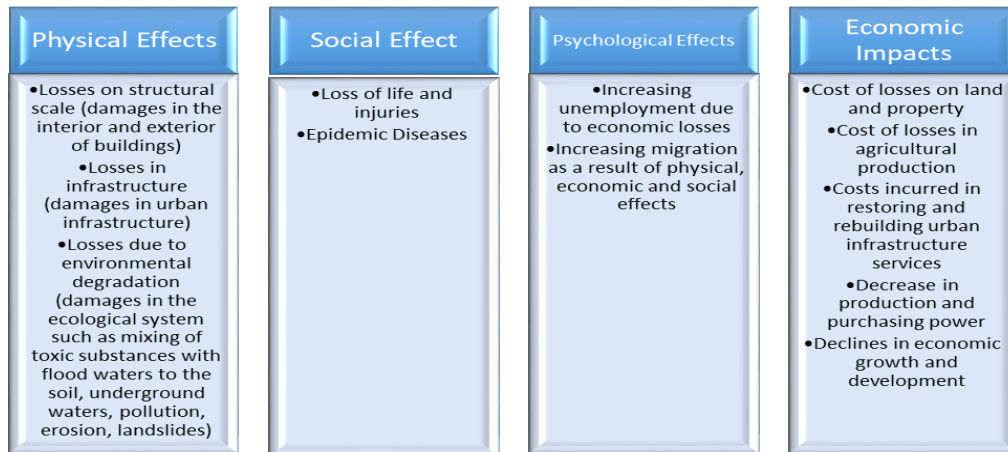


Fig. 3. Urban Impact of Flood (Çetin and Tezer, 2013)

Flood Area Modeling Methods

There are three floodplain modeling methods:

- **Engineering Experience:** The experience and opinions of engineers with hydraulic calculations have been utilized in flood modeling studies for approximately 100 years. Today, all floodplain modeling problems are solved by engineers with significant experience using hydraulic modeling tools.
- **Physical Modeling:** Most physical modeling studies were conducted from the late 1800s to the early 1900s, particularly in the hydraulic laboratories of universities, to investigate waterway-related problems. These models were not directly used in floodplain modeling studies. Recently, physical models have only been created in large hydraulic laboratories when numerical models do not yield satisfactory results.
- **Numerical Modeling:** In the initial studies, analytical procedures were carried out through manual calculations; however, later, computer programs began to be used effectively. Today, the combination of GIS and computer programs is used as the most appropriate technique in flood area modeling studies (Onuşluel, 2005).

Flood Area Determination Processes

Because flooding is a dynamic process, the characteristics of basins, channels, and flood patterns change over time. This means that the conditions that cause floods change over time. The floodplain map is prepared based on present conditions only; it is not used for future projections under current conditions.

Flood maps should be updated using new data that changes over time. Using new techniques, it is possible to create more accurate flood maps that cover larger areas at a lower expense. Accuracy depends on the data used in it and the purpose for which it was prepared. Some flood maps are prepared to show flooded areas. Others are made for flood control projects that require greater accuracy, therefore, more expensive (Wahl et al., 2010).

In traditional flood map production, water level points observed on the topographic map are marked, and these points continue to be marked on the map until the contour lines with higher elevations are reached (Noman, 2001). In recent years, computer modeling techniques have been widely used in water-related studies. Using computer modeling techniques, engineers predict where and when floods will occur (Snead, 2000).

Studying Area

In this study, the section of the Samsun Mert River up to 7251.074 m from the point where it flows into the sea, and the section of Yılanlıdere, a tributary of the river, up to 4150.276 m from the confluence with the Mert River, were chosen as the study area (Fig. 4).



Fig. 4. The study area

The river flows into the Black Sea, passing between the borders of Canik County, which is affiliated with Samsun Metropolitan Municipality in the east, and İlkadım District, within a 10 km development area also affiliated with the Samsun Metropolitan Municipality, in the west. At the edge of Mert River and Yılanlıdere, there are Çay District, Kılıçdede District, Adalet District, Derebağçe District, and Güzeldere District of İlkadım County, Yenimahalle District, Soğuksu District, Gaziosmanpaşa District, and İkiyuzevler District of Canik County. In addition, the study area features one shopping center, an Organized Industrial Zone, and one private hospital.

In the early 2000s, a "flood trap" was established on Yılanlıdere to prevent floods that can be caused by excessive rainfall. The front of this flood trap has been used as a garbage dumping station by the Samsun Municipality for many years. It is then used as an excavation dumpsite to cover this garbage. In the part where Yılanlıdere reaches the Mert River, stream reclamation work was carried out, and the bed of Yılanlıdere was changed with the joint work of the Metropolitan Municipality and DSI, and this bed was taken into an open concrete channel by DSI. Later, the 120 m part of the open canal was covered by the Samsun Metropolitan Municipality. The ring road that was passed over the canal immediately after made the canal also closed in the part where it passed (Anonymous, 2015ac). A part of the flood trap could not withstand the heavy rains that occurred in July 2012 and ruptured at a depth of 5 to 6 meters. Due to this rupture, the water accumulated in the flood trap dragged garbage, excavation waste, tree branches, and other sediment materials stored in front of it. As the closed canal and highway underpass were blocked in a short time, the floodwaters dispersed before they could reach the Mert River, some of them went to TOKİ houses built in the old bed of Yılanlıdere, and some of them went towards the surrounding facilities and small industrial sites following the ring road (Fig. 5).



Fig. 5. Mert River and Yılanlıdere floods in 2012

Creating a Flood Hazard Map of the Mert River and Yılanlıdere

In this study, the water surface profiles of the Mert River and Yılanlıdere were determined using the HecGeoRAS and HEC-RAS (Hydrologic Engineering Centers River Analysis System) programs based on the flow and flood reclamation reports received from Samsun DSI 7. A regional flood hazard map was created for the study area, covering 10, 25, 50, 100, 500, and 1000-year flow rates, before and after the flood reclamation works. The workflow chart of flood mapping is shown in Fig. 6.

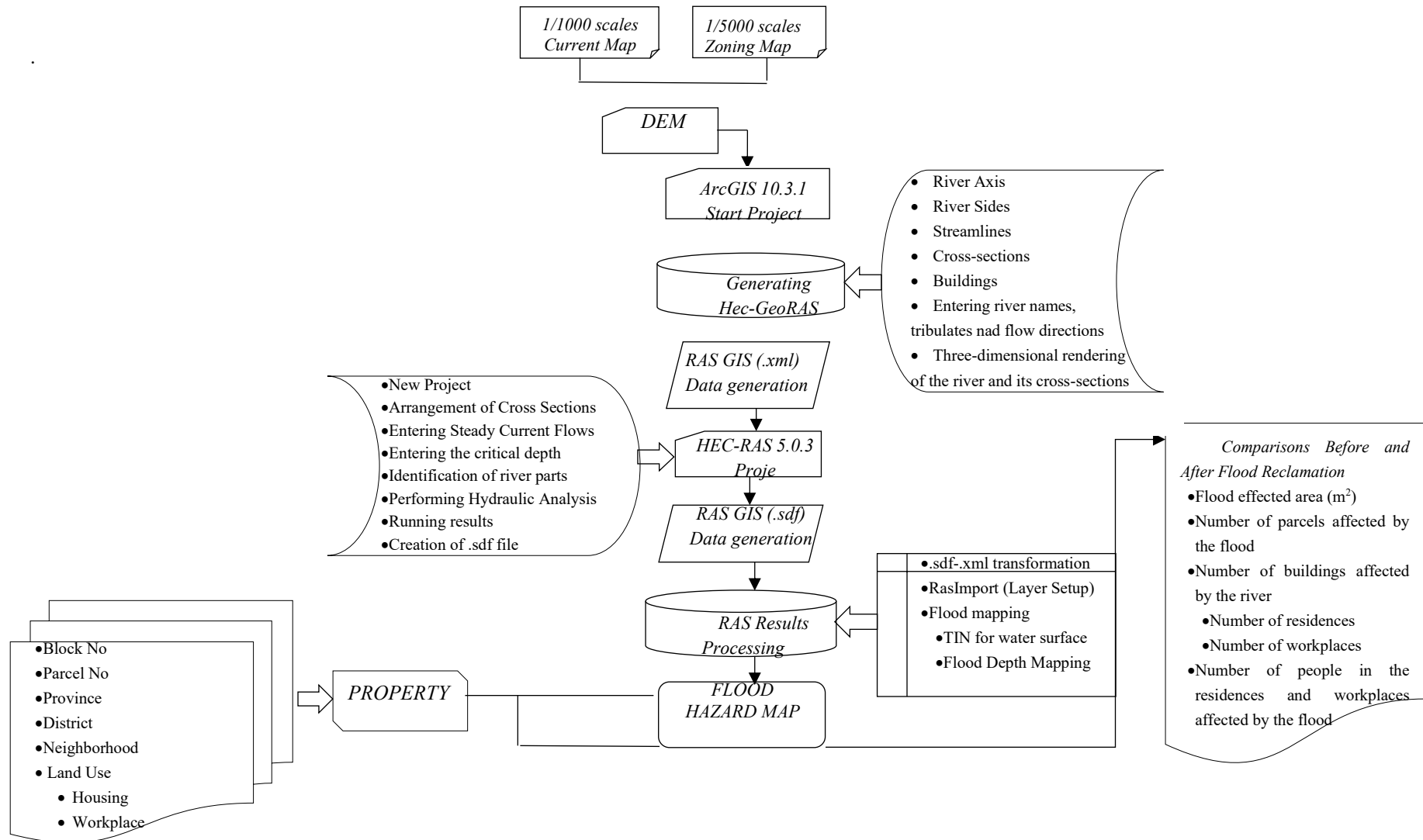


Fig. 6. Flood Hazard Map Workflow Chart

A Digital Elevation Model was created to identify areas that could be flooded during the flood, and geometric data were prepared in HECGeoRAS. Geometric data were processed in HEC-RAS according to the flow rates (Q_{10} , Q_{25} , Q_{50} , Q_{100} , Q_{500} , Q_{1000} , Q_{2012}) provided, and the results were mapped again in HEC-GeoRAS (Fig. 7)

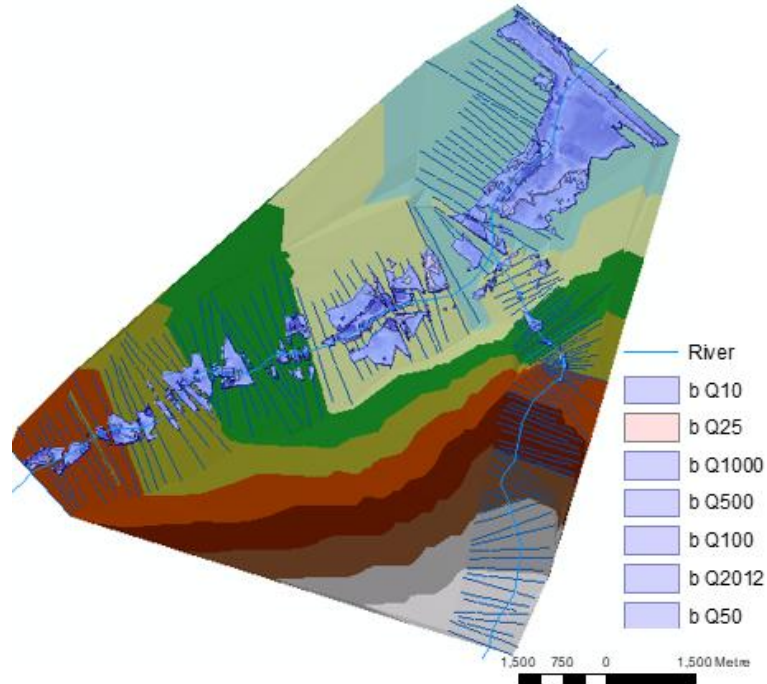


Fig. 7. Floodplain of the study area

Requirements Analysis

After the requirements obtained as a result of various methods are grouped according to their characteristics, requirements analysis studies are carried out to make the system ready for design. As a result of this study, requirements analysis studies were carried out in 6 stages to obtain the flood risk map correctly and establish a property relationship with the buildings in these areas (Fig. 8).

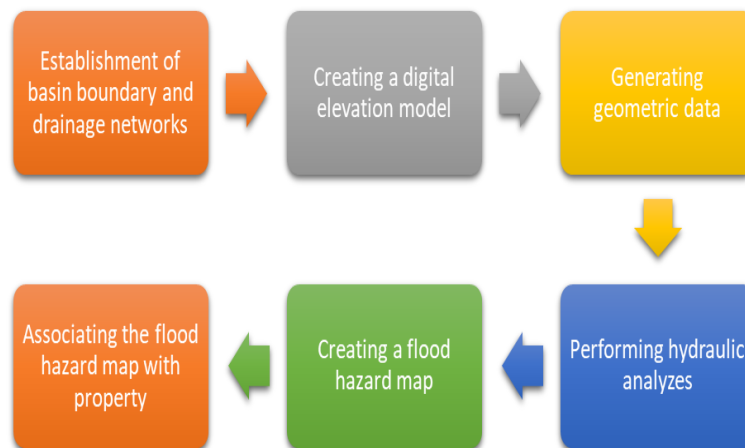


Fig. 8. Requirements analysis process steps

First, the entire basin boundary and drainage networks of the studied part of the river were obtained. In the second stage, a Digital Elevation Model was created using the supplied data. Geometric data, including river axis, river width, flow direction, buildings, and sections, were created over the DEM obtained in the third stage. In the fourth stage, hydraulic analyses of the geometric data generated by the project and flow data were conducted. In the fifth stage, a flood hazard map was created with this data. At the final stage, the ownership status of the

immovables in the flood-affected areas was examined using the flood risk map, and it was estimated how many people would be affected by these floods.

Results and Discussion

With the use of GIS software, the accuracy of data such as maps, satellite images, and hydraulic and hydrological parameters obtained from institutions will increase the sensitivity of the flood hazard map. In this study, the necessary 65 pieces of 1:1000 base maps and 2 pieces of 1:5000 zoning plans were obtained from Samsun Metropolitan Municipality, and hydraulic and hydrological data were obtained from the Samsun DSI 7th Regional Directorate. These values are shown in Table 1.

Tab. 1. Calculated flow (Q) values of the Mert River and Yılanlıdere according to different years

	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{500}	Q_{1000}	$Q_{2012\text{YEAR}}$
MERT 1	1363.7	1800.2	2179.5	2612.8	3698.8	4371.4	5758.6
YILANLIDERE	80.1	119.6	155.7	197.6	279	314	710

Then, with the help of this data obtained, flood hazard maps are created before and after the reclamation of the study area by using GIS and modeling software, and for each flow rate, how many square meters of the area it covers in the flood area and the number of buildings and parcels as residences and workplaces in these areas are determined. Additionally, the number of people affected by these floods is determined. In Fig. 8, as an example, the areas remaining in the flood area, which were created according to the flood flow rate that occurred in 2012, before and after the flood reclamation work was carried out, are shown. Before the flood reclamation work was carried out here, a total area of 2787986.789m² remained within the flood area. In 2014, flood reclamation works were carried out by the Samsun DSI 7th Regional Directorate and Samsun Water and Sewerage Works in accordance with the 10-year flood flow. If flood reclamation had been carried out before the flood, it would have covered an area of 2678714.896m² with a reduced rate of 3.92% (Fig. 10). In the flood that occurred in the study area in 2012, a total of 2896 parcels remained in the flood area. If flood reclamation work had been carried out before the flood, 2725 parcels would have remained in the flood area with a 5.9% reduction rate. Fig. 10 shows the parcels remaining in the flood area.

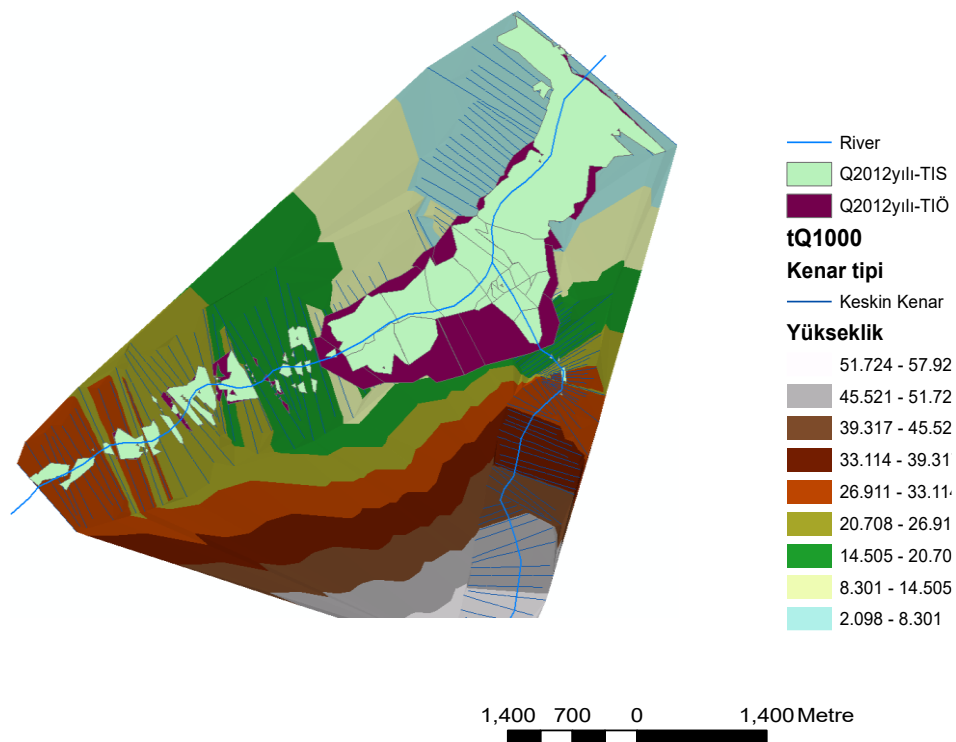


Fig. 9. After Flood Reclamation, the areas remaining in the flood area at the Q2012 flow rate (Q2012-AFR)

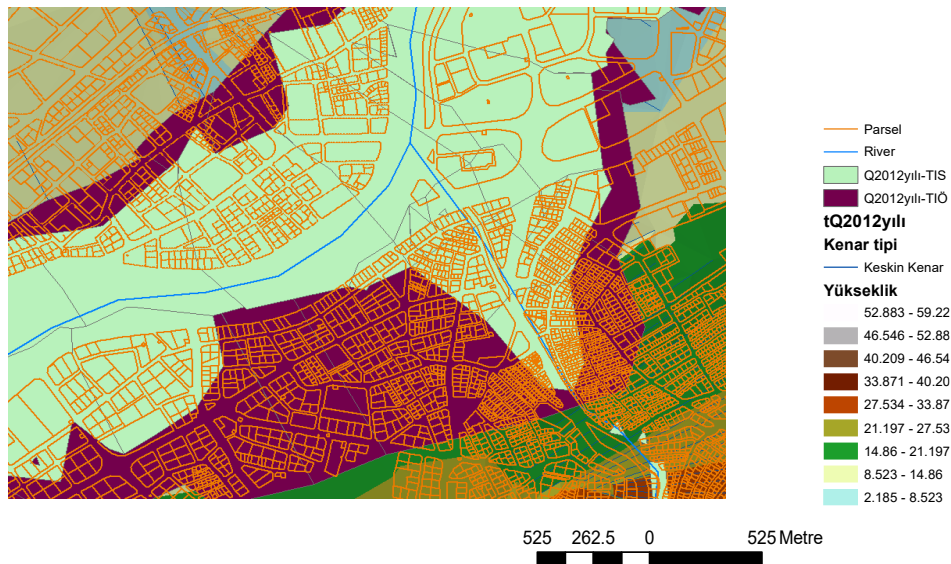


Fig. 10. Example of parcels remaining in the flood area at the Q_{2012} flow rate after Flood Reclamation (Q_{2012} -AFR)

In Table 2, the number of areas, buildings, and parcels, as well as the reduction rates in the areas remaining within the flood area before and after the flood reclamation work in the entire study area, were determined separately for each flow rate. According to this, if the flood reclamation work according to Q_{10} had been carried out before 2012, there would have been a 3.92% decrease in the flood area and a 5.9% decrease in the number of parcels.

Tab. 2. Flood areas and the number of buildings entering these areas according to the flood recurrence rates of the Study Area before the flood rehabilitation work was carried out.

Q Flow	Situation before the flood reclamation work			Situation after flood reclamation work			Reduction Rate After Flood Reclamation Work %		
	Area (m ²)	Number of parcels	Number of buildings	Area (m ²)	Number of parcels	Number of buildings	Area	Parcel	Buildings
Q_{10}	1821037.714	1514	617	1591513.263	1183	509	12.60	21.86	17.50
Q_{25}	1998066.926	1723	701	1773678.522	1359	612	11.23	19.96	12.70
Q_{50}	2185004.997	1859	821	1961756.015	1513	727	10.22	18.61	11.45
Q_{100}	2370500.045	2076	922	2165673.792	1758	837	8.41	15.32	9.22
Q_{500}	2549901.225	2314	974	2419647.338	2076	907	5.11	10.28	6.88
Q_{1000}	2697487.537	2678	1068	2588105.571	2482	1013	4.05	7.32	5.15
Q_{2012} yılı	2787986.789	2896	1272	2678714.896	2725	1217	3.92	5.9	4.32

Fig. 11 shows the number of buildings that will be affected by possible floods in the Yılanlıdere tributary of the Mert River. Accordingly, the number of buildings decreased by 7 in Q_{10} flow, 6 in Q_{25} flow, 6 in Q_{50} flow, 3 in Q_{100} flow, 2 in Q_{500} flow, 3 in Q_{1000} flow, and 4 in 2012 flood flow (Q_{2012}).

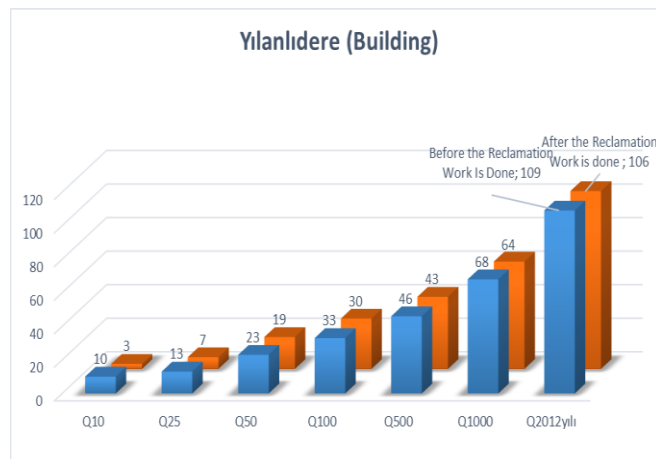


Fig 11. Demonstration of flood-affected buildings in Yılanlıdere before and after the rehabilitation work

The number of buildings that may be affected in case of a possible flood that may occur in the main tributary of the Mert River is shown in Fig. 12.

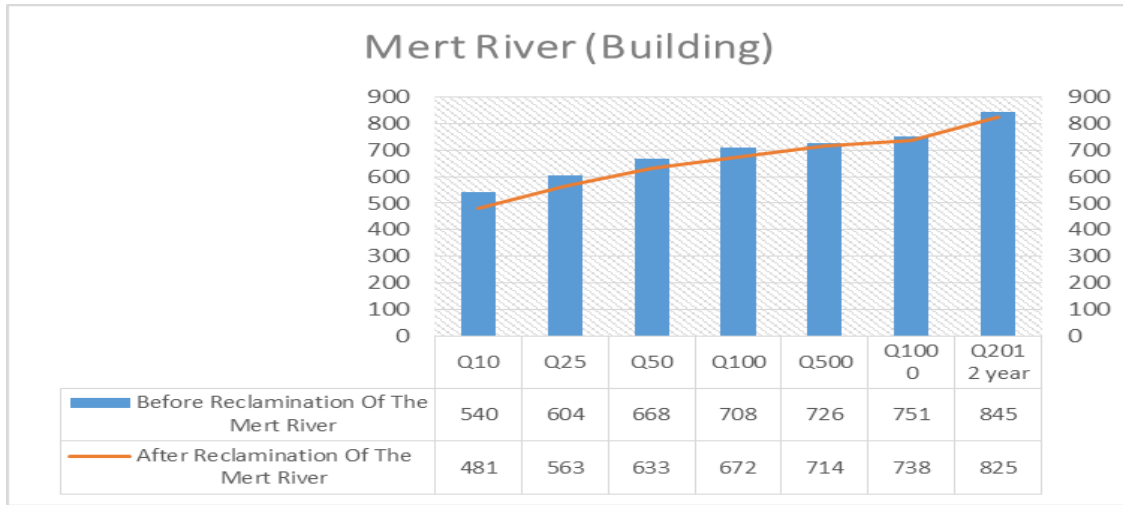


Fig. 12. Demonstration of the buildings affected by the flood before and after the reclamation of the Mert River

To find the number of people in the buildings in Kılıçdede, Çay, Derebahçe Districts of Ilkadım County, and Kuzey Yıldızı, Yenimahalle, and Gazi Districts of Canik County that may be affected by floods, the ownership status of the buildings in the flood area was obtained from the Prime Ministry Disaster and Emergency Management Improvement Department and Samsun Land Registry and Cadastre Directorate. In these data, the parcel's island number, parcel number, district name, type (whether it is a plot of land, whether there is a building on it, how many floors these buildings are, these buildings are used as residences or workplaces, the number of independent sections there) and surface area. The zoning (plot layer) data obtained graphically and the data taken from the title deed were combined. In the flood hazard map obtained, the existing flood areas and the parcel layer were combined again according to the flood recurrence rates, and by making the necessary inquiries, the number of buildings in the flood areas based on the district, the number of independent sections used as residences or workplaces of the independent sections and the number of people in the independent sections that may be affected by the flood, their conditions before and after the flood reclamation work, and the reduction rates that may occur before the flood reclamation work (BFR) and after the flood reclamation work (AFR) are investigated in Tab 3.

Tab. 3. Number of buildings, independent sections, and people that may be affected by the flood before and after the flood reclamation

Q Flo w	Total Buildings			Number of Independent Sections						Number of Persons					
	Affected Number			Residence			Workplace			Residence			Workplace		
	BF R	AF R	Differen ce (%)	BF R	AF R	Differen ce (%)	BF R	AF R	Differen ce (%)	BFR	AFR	Differen ce (%)	BF R	AF R	Differen ce (%)
Q ₁₀	617	509	17.5	229 0	209 2	8.65	555	498	10.27	1117 6	9809	12.23	332 6	319 8	3.85
Q ₂₅	701	612	12.7	290 5	267 5	7.92	606	546	9.9	1278 2	1132 9	11.37	365 3	354 6	2.93
Q ₅₀	821	751	11.45	317 6	295 4	6.78	703	656	6.68	1353 5	1209 8	10.62	421 8	411 6	2.41
Q ₁₀₀	922	854	9.22	383 2	364 2	4.96	714	679	4.9	1646 2	1508 0	8.39	428 4	418 8	2.24
Q ₅₀₀	974	921	6.88	379 6	368 8	2.84	736	706	4.08	1670 2	1562 7	6.44	440 6	432 0	1.95
Q ₁₀₀₀	1068	1016	5.15	391 1	383 0	2.07	831	817	1.68	1700 9	1657 6	2.55	498 6	490 2	1.68
Q _{201 2}	1272	1237	4.32	494 8	487 5	1.47	904	895	0.99	2177 1	2145 1	1.47	540 0	535 8	0.78

In Table 3, when calculating the number of people to be affected based on the district in the flood-prone area, the average number of people per household in Samsun is considered to be 4.4, according to 2016 data obtained from the Turkish Statistical Institute. According to the April 2017 data obtained from the Social Security Institution's Samsun Ilkadım and Canik County Directorate, there are 7,964 active workplaces in Ilkadım County, and a total of 48,197 workers are employed in these workplaces. In Canik County, there are 1,986 active workplaces, and 11,330 workers work in these workplaces. According to these data, it is assumed that an average of 6 workers work in a workplace. According to these data, in the 10-year flood flow rate of 721.9 m³ /sec for Mert River and 80.1 m³ /sec for Yılanlıdere, after the flood reclamation work is done, the number of buildings affected

by the flood will decrease by 108, the number of independent sections used as residences will decrease by 198, the number of independent sections used as workplaces will decrease by 57, the number of people living in the residence will decrease by 1,367 and the number of employees in the workplace will decrease by 128 if flood reclamation was carried out before 2014.

According to the flood flow that occurred in 2012, the number of buildings affected by the flood would have decreased by 35, the number of independent sections used as residences would have decreased by 73, the number of independent sections used as workplaces would have decreased by 11, the total number of independent sections would have decreased by 84, the number of people living in the residence would have been reduced by 320 and the number of employees at the workplace would have decreased by 54. In Table 4, there are 422 buildings in Kılıçdede, Derebahçe, and Çay districts in Ilkadım County, which were included in the flood hazard map at the Q_{2012} flow rate before the flood reclamation work was carried out. There are a total of 2,290 independent sections, of which 2,150 are residential and 140 are workplaces. Within these independent sections, there are 9,460 households in residences and 840 working people in workplaces. In the Kuzey Yıldızı, Yenimahalle, and Gazi districts of Canik County, the total number of buildings is 850, of which 2,798 are residences, a total of 3,558 free sections, and 760 of which are workplaces. In these independent sections, there are 12,311 households in residences and 4,560 employees in workplaces. In total, before the flood reclamation work is implemented in Q_{2012} , 1,272 buildings, 5,848 free sections, of which 4,948 are residences and 904 are workplaces, and 21,711 people in residences and 5,400 people in workplaces in these independent sections will be affected by flooding (Table 4).

Tab. 4. According to the flow rate of Q_{2012} , the independent sections entering the flood area and the number of affected persons before the flood reclamation work

District	Neighborhood	Number of buildings (Domestic and Workplace)	Number of Independent Sections		Total Number of Independent Sections	Number of People Affected by the Flood	
			Residence	Workplace		Residence	Workplace
İlkadım	Kılıçdede	282	1,342	83	1,427	5,905	498
	Derebahçe	117	386	57	443	1,698	342
	Çay	23	422	-	422	1,857	-
TOTAL		422	2,150	140	2,290	9,460	840
Canik	Kuzey Yıldızı	367	1,420	81	1,501	6,248	486
	Yenimahalle	286	753	604	1,357	3,313	3,624
	Gazi	197	625	75	700	2,750	450
TOTAL		850	2,798	760	3,558	12,311	4,560
GRAND TOTAL		1,272	4,948	904	5,848	21,771	5,400

After the flood reclamation work carried out in 2014, the number of buildings in Kılıçdede, Derebahçe and Çay Districts in the Ilkadım County decreased to 413, the number of residences to 2,118, the number of workplaces to 137, and the number of independent sections to 2,255 in total, in the flow rate of Q_{2012} . In these independent sections, there are 9,320 households in residences and 822 working people in workplaces. The total number of buildings in the Kuzey Yıldızı, Yenimahalle, and Gazi Districts of Canik County has decreased to 824, comprising a total of 3,513 independent sections, of which 2,737 are residences and 776 are workplaces. In these independent sections, there are 12,131 households in residences and 4,356 working people in workplaces. In total, before the flood reclamation work is implemented in Q_{2012} , 1,272 buildings, 5,848 free sections, of which 4,948 are residences and 904 are workplaces, and 21,711 people in residences and 5,358 people in workplaces in these independent sections may be affected by flooding (Table 5).

Tab. 5. The independent sections entering the flood area and the number of affected people after the flood rehabilitation work according to the flow rate of Q_{2012}

District	Neighborhood	Number of buildings (Domestic and Workplace)	Number of Independent Sections		Total Number of Independent Sections	Number of People Affected by the Flood	
			Residence	Workplace		Residence	Workplace
İlkadım	Kılıçdede	283	1,327	81	1,409	5,839	486
	Derebahçe	107	369	56	424	1,624	336
	Çay	23	422	-	422	1,857	-
TOTAL		413	2,118	137	2,255	9,320	822

	<i>Kuzey Yıldızı</i>	362	1,397	80	1,478	6,147	480
Canik	<i>Yenimahalle</i>	279	748	604	1,350	3,291	3,624
	<i>Gazi</i>	183	612	72	685	2,693	432
TOTAL		824	2,737	756	3,513	12,131	4,356
GRAND TOTAL		1,237	4,875	893	5,768	21,451	5,358

According to these data; after the flood reclamation work was carried out, the number of buildings affected by the flood decreased by 35, the number of independent sections used as residences decreased by 73, the number of independent sections used as workplaces decreased by 11, the total number of independent sections decreased by 84, the number of people living in the residence decreased by 320 and the number of employees in the workplace decreased by 54.

Conclusions

In the flood hazard maps created in this study, firstly, according to the 10, 25, 50, 100, 500, 1000-year flood recurrence rates obtained by Samsun Metropolitan Municipality and the 7th Regional Directorate of State Hydraulic Works by calculating according to the Mockus method, and according to the flood flow rate that occurred in 2012, Yılanlıdere while the 1000-year flow rate of the river was $Q_{1000}=314\text{m}^3/\text{sec}$, the flow rate of Yılanlıdere in the flood that occurred in 2012 was determined as $Q_{2012}=710\text{m}^3/\text{sec}$ (ie catastrophic flow). This means that the river's flow has increased to a catastrophic extent. According to the flood recurrence rates from flood hazard maps obtained, the number of buildings entering the flood area, the number of independent sections used as residences and workplaces, and the number of people who may be affected by the flood were examined, it was determined that there were 617 buildings, 2290 residences and 10076 people residing in the flood area, 555 workplaces and 3,300 workers in the Q10 flow. In the flooding that occurred at a 10-year flow rate after the flood reclamation work, it was determined that 509 buildings entered the flood area, 9,809 people were affected in these buildings, and 2,958 employees in the workplaces were affected by the flood. The flood hazard map created reveals that flood reclamation work carried out in anticipation of a flood event with a Q10 flow rate significantly reduces flood damage, but it is not sufficient.

The Turkish Catastrophe Insurance Pool (TCIP) (Doğal Afet Sigortaları Kurumu-DASK) can serve as a model institution for implementing the concept of Compulsory Flood Insurance (TASK). Since being sufficiently accurate and up-to-date with current maps and zoning plans used to obtain flood hazard maps will increase the reliability of flood hazard maps, these maps need to be updated frequently. It is necessary to correct existing development plans implemented on riverbanks or to prepare flood hazard maps before constructing new plans, and to accept them as data in the zoning plan. According to Article 23 of the Type Zoning Regulation in Planned Areas, structures within the flood protection band should be removed and included in the scope of urban transformation. These areas should be designated as "areas to be afforested." Since the flood event cannot be completely prevented in our country, it is necessary to implement the concept of "flood insurance", as in developed countries such as America, England, etc., to prevent some of the financial losses of the flood without harming the state budget. For this, flood hazard maps should be created using the latest technologies, such as UA and GIS, they should be constantly updated, and hazard mitigation measures should be taken. In addition, by making legal arrangements on this subject, it is necessary to raise awareness of the public about floods and damages by issuing necessary policies for flood insurance with private insurance companies and government partnerships, as well as the implementation of the Compulsory Flood Insurance (TASK) (Zorunlu Taşkın Sigortası) concept, similar to the Compulsory Earthquake Insurance, and making it permanent.

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