



Rapid identification of flood-prone settlements in the Eastern Mediterranean Basin in Turkey

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Abstract

Territories and settlements in low plains are at risk of flooding. Therefore, determining the areas at risk of flooding before preparing city plans or country development plans is essential. The number of hydrological models is increasing day by day; on the other hand, the solution of these models requires too many parameters. Long-term measurements are required to perform flood analysis with these models. However, in some regions, data from previous years may not always be available. Therefore, a method that enables the determination of flood-prone areas in a short time based on historical records is proposed in the current study. In the current study, the Eastern Mediterranean basin has an area of 21,682 km² was examined. Using geographic information system (GIS) and the current population information (growth trend) as well as evaluating the historical process and archival records, 157 flood-prone settlement areas were identified. Different flood scenarios were examined and settlement areas that needed to be further examined by modeling were digitized. We aimed to create a base for basin-based flood modeling and to provide information about flood-prone areas to local administrators for national and local plans.

Keywords Flood risk · GIS · Digitization · Alluvium method · Geomorphology · Eastern Mediterranean Basin

Introduction

Considering the impact of global warming and climate change; It is estimated that natural disasters cause an average of more than 300 billion dollars in direct financial losses every year (Hallegatte et al. 2017). Moreover, while every country faces natural disasters such as earthquakes, hurricanes or wildfires, floods are among the most common and serious hazards worldwide. In order to reduce disaster damage, it is important to know the flood risk areas in advance and to take precautions.

The amount of water in a riverbed can increase rapidly due to rainwater and snowmelt; thus, the river overflows and causes damage to the living creatures, lands, and properties in the vicinity. This is called a flood event (Seçkin and Topçu 2016). To protect against flood events and to minimize damage, structures in flood-prone areas must be designed considering the maximum flood magnitude. Prediction of a flood event in a basin is an important and challenging issue since

such an event depends on hydrological data with random properties. In the calculation of hydrological data, deterministic methods that require establishing mathematical relations between variables or statistical analysis are used (General Directorate of State Meteorology 1990). In places with few or no hydrological measurements, it is therefore difficult to envisage appropriate project criteria for the planning and management of water resources (Anli et al. 2008). To prevent such problems, hydrological data from stations in the immediate vicinity with similar properties can be used. This method is called regional frequency analysis and refers to the process of applying data from different measurement stations with similar characteristics (Durrans and Kirby 2004; Hosking and Wallis 2005).

Previous studies have revealed that inundations and floods can affect human health in two ways: 1. Direct effects, 2. Indirect effects (Menne et al. 1999). Direct effects are usually caused by floodwaters and include drownings, injuries, and others. Indirect effects, on the other hand, are the effects caused by other mechanisms related to flooding. Infections caused by water, acute and chronic effects of exposure to chemical pollutants released in floodwater, lack of food, etc., can be given as examples of such effects ((WHO) et al. 2002). The effects of inundations and floods on human

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health may occur immediately (death, injuries, etc.), after a comparable period, or in the years following the event (diseases, etc.) (McMichael et al. 2001). In a more general approach, the impacts of inundations and floods on human health fall into two categories: physical effects and psychological effects. Physical effects include those caused during flood events, the reasons related to the cleaning process, consequences of displacement of people, and the damages to the infrastructure system. On the other hand, direct psychological effects are created by experiencing inundation and floods. However, indirect psychological effects may occur during a restoration practice (Hajat et al. 2003). In this respect, it is imperative to identify areas at risk of inundation or flood.

Many studies were carried out on the determination of flood-prone settlements, which is also closely monitored by insurance companies (Dubbelboer et al. 2017). Several methods were applied for the estimation of flood risk at a river basin using morphometric parameters. Various classification studies were carried out on the physical characteristics of the basins (El-Shamy 1992; Reddy et al. 2002; Youssef et al. 2011; Abdul Rahaman et al. 2015; Meshram et al. 2017; Rai et al. 2017; Malik et al. 2019; Arulbaraji et al. 2020). Furthermore, drainage characteristics of the basins were also examined according to the geometric sizes (Horton 1945; Miller 1953; Schumm 1956; Strahler 1964). Generally, a relationship between the geomorphological properties of the basin and its hydraulic properties was investigated (Aher et al. 2014; Asode et al. 2016; Rahaman et al. 2015; Yadav et al. 2014; Kumar et al. 2000). Accordingly, a relationship between the basin's morphometric structure and the drainage network was determined in many studies (Horton 1932; Leopold and Miller 1956; Markose et al. 2014). On the other hand, some studies examined only the interaction between river networks and the basin's morphometric structure (Jolly 1982). The morphometric correlations were used for stream hydraulics, flood prediction, pollution, and sediment modeling (Koçyiğit and Akay 2018; Ogunkoya et al. 1984; Ozdemir and Bird 2009; Pitlick 1994; Shi et al. 2014; Sreedevi et al. 2005). Morphometric properties were also used in the groundwater modeling (Akram et al. 2009) and to examine their associations with hydrological parameters (Deepika et al. 2013; Patel et al. 2013).

Evaluation of morphometric analysis of flash flood potential of Eastern Mediterranean Basin using principal component analysis (Koçyiğit et al. 2021). An analysis based on the flood archive records and population in the basin with physical characteristics is believed to contribute to filling a gap in the literature. A base was created on the map with the points that remained the same or increased in the population growth trend in the settlements. Alluvial areas and areas that overlap with data bases created by water raising were evaluated. The water raising method, also called the Exzesco method, is mostly used in France and Romania. Risk

situations are taken into consideration when determining the water height. Up to 0.5 m, some risk to the lives of vulnerable groups such as children and the disabled should be expected. At heights of up to 1.5 m, a significant portion of the affected population may face life-threatening risks with the flood waters. Above 1.5 m, most casualties are at significant risk to life unless rescue measures are taken (Rentschler and Salhab 2020). In this study, a height of 1.5 m was determined as a very high-risk level for water raising to the determined rivers.

Historical records method is used mostly in America by looking at plant roots as well. It is possible to evaluate the determination of flood-risk areas according to alluvial areas from an economic and strategic point of view. However, in this study, in which human life is prioritized, population information was also evaluated.

Therefore, in the current study, the Eastern Mediterranean basin has an area of 21,682 km² was examined using different basin parameters like alluvial parameters. Also, historical processes and archival records were investigated using current population information with the help of Geographic information system (GIS). 157 settlements (residential areas) with high flood risk were determined. These settlements were digitized according to different flood scenarios for further analyses and modeling.

Study area and data

An evaluation was conducted for the Eastern Mediterranean basin considering the topography, creek and river routes, natural catchment areas, floodplains, general hydrological and geological features, the effectiveness of existing man-made infrastructures against floods, settlement locations, economic activity areas, strategic structures, and possible effects of climate change, as well as potential adverse effects of past and the future floods on human health, environment, cultural heritage, and economic activities. All parameters, directly or indirectly, were taken into account in the determination of the litter created while making the preliminary assessment of the flood risk.

Based on these evaluations, flood risky areas in the basin were identified. Concerning the potential flood events, the remaining alluvium assessment in agricultural areas, settlements, and areas of economic activity were evaluated. The 2015 data generated by the Turkish Statistical Institute (TurkStat) was used to determine populations at risk of flooding. Population records in the settlements in the basin were taken for 826 places and added to a table. According to the data obtained, the highest population is Toroslar district with 335,587, and the places where the population is below 100 were not evaluated in terms of risky areas.

Within the scope of the study, the digital lithology map of the Eastern Mediterranean Basin prepared by Mineral Research and Exploration (MTA) was examined. Alluvial units in the studied lithological units were separated from other lithological units in the GIS environment and the alluvial floor of the region was formed. Afterwards; It has been added as a separate layer to the GIS bases (intersecting with the settlements) to be used in flood risk preliminary studies.

Of the 5 basic and 44 sub-classes of land use, prepared on the recommendation of the European Environment Agency; areas of economic importance such as residential areas, industrial and commercial areas were used. It has been determined that the polygons obtained from the CORINE 2012 data do not include all of the current settlements in the Eastern Mediterranean Basin. Since the Eastern Mediterranean Basin is generally composed of mountainous areas; settlements are scattered. For this reason, more settlements than the polygons specified in the CORINE 2012 data were additionally identified. In this direction, new settlements were added to the study as points, based on Google Earth and raster topographic maps. The settlement coordination information obtained from the (CORINE) land use map (polygon) and identified on Google Earth was transferred to the Geographic Information System (GIS) software. The current alluvial sites obtained from the Eastern Mediterranean Basin's geological maps were superimposed onto areas with high economic value such as residential areas and industrial areas, and flood risky areas were determined using GIS according to alluvial sites (Fig. 1).

To conduct a flood risk assessment, a GIS program must be used. In the current study, the integrated geographic information system (ArcGIS) program was used as GIS

software. The settlements in the Eastern Mediterranean basin were obtained from CORINE, controlled, and then superimposed onto modern alluvial sites. The past floods in the basin reported by the State Hydraulic Works (DSI) were evaluated using the water-raising method. The last flood event that resulted in loss of life in the region occurred on 28 December 2016 as a result of the flooding of Yalınak Stream in Güneykent District of Toroslar District. To implement the above-mentioned methods, databases were prepared in advance. Then, the resulting data were overlapped with these databases and the required data corrections were then performed. 157 areas at risk of flooding were identified in the basin. For each of the 826 settlements in the basin, the historical record, alluvial status and whether they are risky as a result of water raising were employed in the table. The numerical summary of the results was given in Table 1.

Accurate determination of the basin topography plays a key role in determining flood prone areas (Gulbaz et al. 2017). Mersin province is located in the Western and Central Taurus Mountains and a large part of the Eastern Mediterranean Basin is within the borders of the city. The Taurus Mountains lie in a west–east direction between the Konya plain of Central Anatolia and the Mediterranean Sea. Inside the basin, the number of flat areas between the mountains increases from east to west. The first mountain branch passes through the Northern Districts of Alanya and Gazipasa and extends to Silifke.

On the other hand, the second mountain branch enters Mersin between Ermenek Goksu Valley and Hadim Goksu Valley and ends in the southwest of Mut, where both valleys merged. The Central Taurus Mountains separate Southern Anatolia from the central Anatolia region as a wall-like

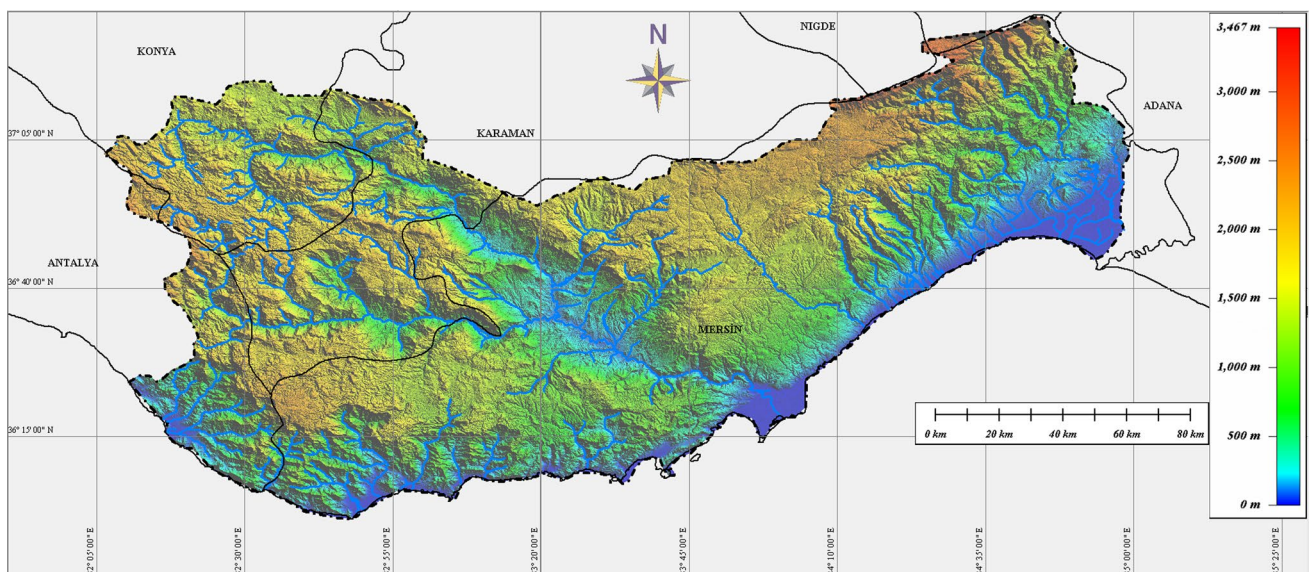


Fig. 1 Basin boundary and rivers of the Eastern Mediterranean Basin

Table 1 Evaluation table of settlements for the Eastern Mediterranean Basin

Evaluation	Status	Total
Pre-modeling assessment	Settlements that are not in the alluvial area	568
	Settlements have a population below 100	72
	Settlements that were found to be not risky by the field study	29
	Total number of settlements found to be not at risk for flooding according to the evaluation criteria	669
Modeling Study-1	Settlements at risk for flooding according to all evaluation methods	41
Modeling Study-2	Settlements found to be at risk for flooding due to only past flooding events	59
Modeling Study-3	Settlements located only on large tributaries (Tributaries No. 4, 5, and 6) and should be examined by further analyses	18
Modeling Study-4	Settlements that only fall within the scope of law No. 4373 and should be examined by further analyses	5
Modeling Study-5	Settlements currently located on alluvial sediments	34
Total	Number of settlements determined to be examined by further analyses using hydraulic modeling	157

structure. Transport from the northeast of Mersin to Central Anatolia can be made through the Gülek Strait (1050 m) between the Bolkar Mountains and the Akdağlar, and the Sertavul (1610 m) pass located in the northwest of Mersin (Fig. 2).

Yenice and Tarsus Plains and the triangular-shaped alluvial valley around Mersin are the most sweeping plains on the eastern coast of the city. In many places, the Taurus Mountains descend to the Mediterranean Sea as steep slopes with forests and scrubs. The plains lie as narrow lanes between the coastline and the mountains. In addition to the Berdan, Efrenk, Gilindires, Ovacık, and Kurvibuk plains, there are many other fertile plains. The streams are short and their beds are sloped, except Goksu and Tarsus creeks,

which are the largest streams in the basin. They flow through narrow valleys and often have no alluvial channel along the bed. Alluvial plains were formed at the places where they reached the sea. The study area is located in the Eastern Taurus Mountains and covers vast areas (Goncuoglu and Turhan 1984; Sengör and Yilmaz 1981).

The Eastern Mediterranean basin consists of steep, sloped highlands and has a dense stream network. These streams have high superflow regimes since spring, summer, autumn, and winter precipitation regimes are irregular throughout the year; therefore, their flow regimes are also irregular. The basin has two major streams, Goksu and Tarsus (Berdan) streams. Gilindires, Tece, Efrenk (Mufti) creeks, and Deliçay brook are the other streams in the basin. Since these creeks

**Fig. 2** Lake and stream map of the Eastern Mediterranean Basin

and brooks are fed by precipitation, some have no water in the summer season. The total area covered by lakes is 19.92 km². The total area of the Eastern Mediterranean Basin, which carries water to the Mediterranean Sea, has 21,682.8 km².

Temporary lakes include the old river branches in the east, which act as a drainage area today, and parts of Incekum submerged by strong winds and/or high precipitations. Rice fields in the basin can also be considered temporary lakes (Kaya 2015).

The common aquifer rocks in the basin are Paleozoic aged marbles, Mesozoic and Neogene aged limestones, and Quaternary alluvium (Okay 2008; Ozgul 1976).

Mersin constitutes an important part of the Eastern Mediterranean Basin and the domestic industry is important in the city in addition to the agricultural sector. Considering the economic status, geographical location and main advantages such as transportation facilities, land conditions, water and energy resources, Mersin has also some other important characteristics that strengthen the development of industry in the city such as its location near the sea coast, close to raw material sources, and is a free zone. Moreover, the city has Mersin port (Turkey's third-largest port) and Tasucu Port, its climate is suitable for working in 12 months of the year, and there are road connections with Central, Eastern, and South-Eastern Anatolia regions. The share of the industrial sector in Mersin's gross domestic product (GDP) is 26.6%. The percentage of the added value created by Mersin province in the manufacturing industry of Turkey is 3.05%. According to the results of the 2002 general industrial and business census, Mersin is ranked 8th with a share of 2.33% across Turkey. Furthermore, with an average of 110,624 employees, it is the 11th biggest city in Turkey with a share of 1.71%. Regarding the regional distribution of enterprises in Mersin, 20.3% of them are in Organized Industrial Districts (OID) and small industrial sites (SIS). In addition, the Akkuyu Nuclear Power Plant, which is under construction in the Gulnar District of Mersin, is another structure of strategic importance in the region. The most important energy investment in the region that concerns Turkey is the nuclear power plant. Another important project in the region is the Turkish Republic of Northern Cyprus (TRNC) Water Supply Project. This project consists of a 106 km long line pipe system, 23 km on the Turkish side, 80 km on the sea (66.5 km with a suspended pipe system), and 3 km on the TRNC side.

Another important structure in the project area is the Ermenek Dam, built by the General Directorate of State Hydraulic Works of the Turkish Ministry of Forestry and Water Affairs and is the 2nd highest dam in Turkey with a depth of 218 m. Since the energy generation started (on 14 September 2012), it has contributed approximately 610 million TL to Turkey's economy (General Directorate of Water Management 2016; State Water and Soil Management

Department 2016). There is no intensive industry in the regions of Konya, Karaman, and Antalya provinces within the borders of the Eastern Mediterranean Basin. Gazipasa Airport located in the Gazipasa District of Antalya province is another important structure in the basin. According to the statistical data for the last 4 years, the airport was served approximately 800 thousand people annually both for domestic and international flights (General Directorate of Water Management 2015; Ministry of Forestry and Water Affairs 2013).

The contour lines and peak points on 251 maps (E00 format) with a 1/25,000 scale were converted to an appropriate format for analysis. Then, using these data, the triangular irregular network (TIN), a vectorial numerical terrain model, was created for the whole basin.

To analyze all data in the same GIS environment, WGS 84_ZONE_33N, which was the same system for Raster images and vector data, was used.

Before the field studies in the basin, the physical parameters were identified to determine the basin's geographical characteristics. These parameters consist of the slope, aspect, and relief maps.

The interpretation of the slope map of the Eastern Mediterranean basin obtained by the GIS analysis revealed that there are many plains, especially in the southern part of Tarsus and Silifke as well as in the northern part of the Hadim district. The basin has steep topography, especially in the northwest and northeast of the Anamur and Gazipasa districts. Camliyayla and Toroslar districts have also steep topography. The slope map of the Eastern Mediterranean Basin is given in Fig. 3.

Similar to the determination of the relief and slope maps, the aspect map was also obtained (Fig. 4).

The main lakes in the basin are the Aptal Lake, Akgol and Paradeniz lagoons connected with the sea and are salty. During the winter, the water level varies by 0.4 m depending on the precipitation. Akgol has no connection with the delta basin except groundwater input and is independent of the flow of the Goksu River. Paradeniz and Akgol lakes host flathead mullet, carp, eel, catfish, and some other fish species. Other important permanent lakes are Kugu Lake located between Akgol and Paradeniz, Arapalanı Lake with a high salt ratio in the east of Paradeniz, and the river's new branch to the east.

Methods

The drainage areas of the basin were determined using the hydrological tools in GIS. The steps of the procedure used to determine the drainage areas of the basin are schematically explained with a flow chart and visuals given below (Fig. 5).

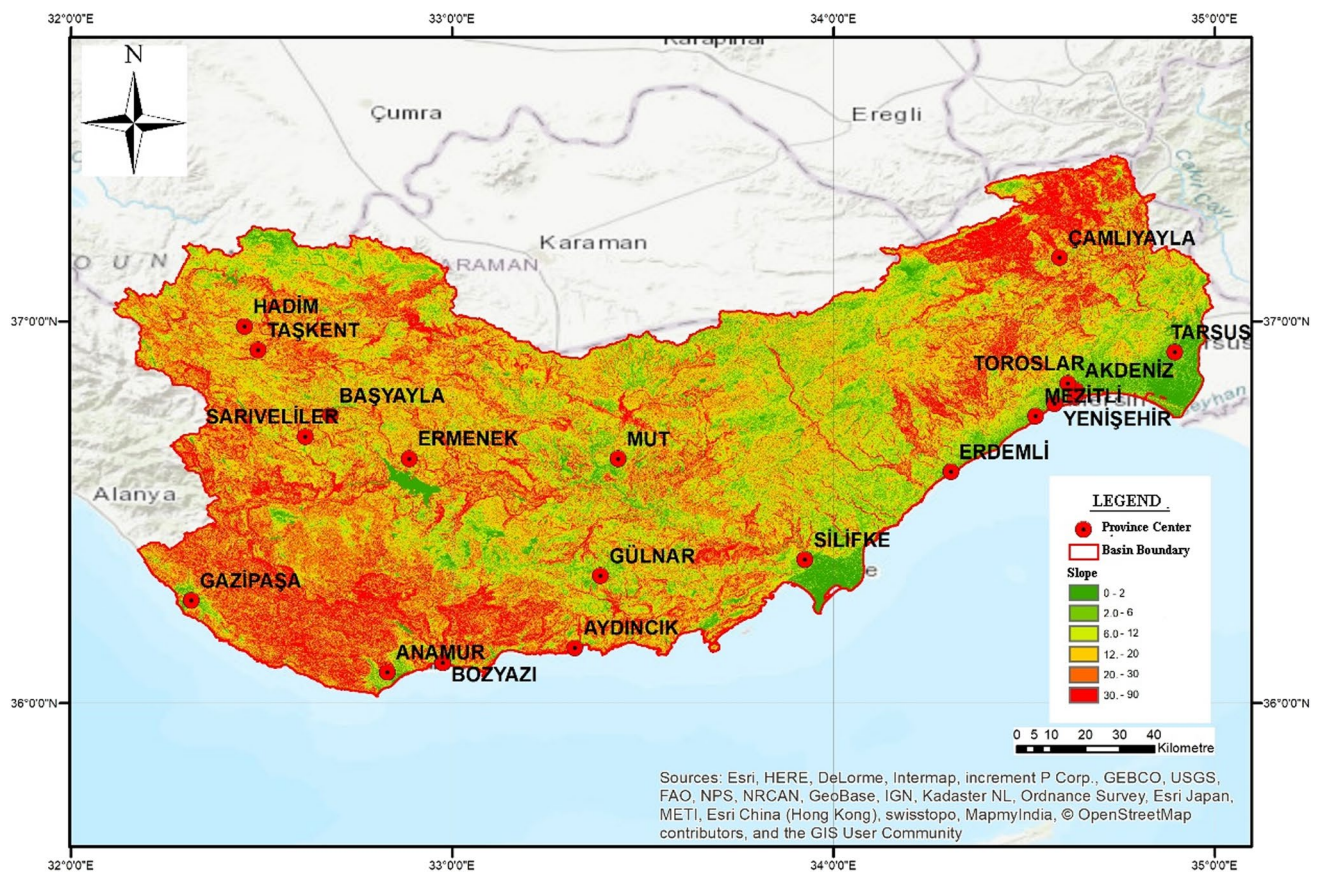


Fig. 3 Slope map of the East Mediterranean Basin

Filling Sinks: To create the surface flow, suitable sink values were defined in the DEM. With the removal of space errors, the flow continues toward cells with lower elevation values.

Determination of the Flow Direction: The flow direction of the basin was determined according to the principle that water flows from a cell toward the cell with the lowest elevation value among eight neighboring cells.

Flow accumulation: By determining the flow accumulation zones, the starting points of the total flow were determined.

Stream Definition: Catchment areas were obtained with the threshold area value determined by the layer value obtained from the flow accumulation zones. Since the stream network can be examined in more detail as the threshold area is smaller, a threshold value of 2 km² was used.

Stream Segmentation: Cell systems were formed using the unique identification number of each stream cell. Stream tributaries with a threshold-area value of 2 km² were obtained in the Eastern Mediterranean basin.

Catchment Grid Delineation and Catchment Polygon Process: In the system, the lowest basin area was 2 km². One

basin area was defined for each stream with water flow and the entire basin was divided into sub-basins.

Drainage Line Process: For each stream basin, streamlines were determined.

Watershed delineation: After the phases defined above were completed virtually, the total basin (watershed) area was obtained.

The Horton-Strahler method was used for ordering. In this method, creeks with no side tributaries start ordering with 1 (1st-order streams), when such a stream joins another stream with the same order, its order increases (Fig. 6). However, if it merges with a river tributary with a smaller order, the ordering does not change. As a result of different analyses, the boundary of the 2 km² river sub-basin and the flow direction were determined; thus, 6 different stream classes were obtained using the Horton-Strahler method. The total lengths of the stream tributaries calculated according to the Horton-Strahler method are given in Fig. 7.

The CORINE Land Use Map was used for determining the residential areas. We decided to use regions with economic importance, such as settlements, industrial and commercial areas, from five primary and forty-four sub-land use classes prepared according to the recommendation of the

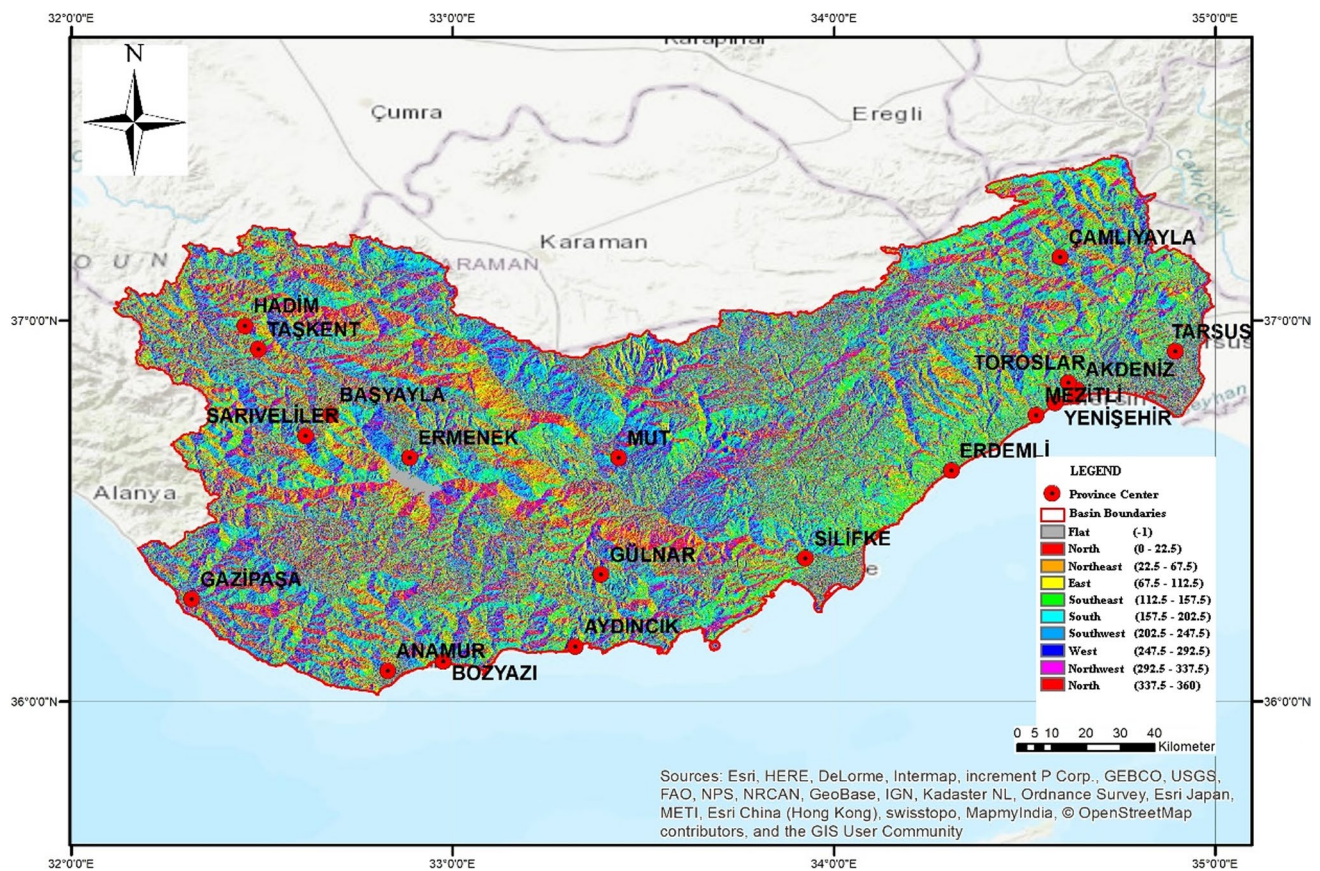
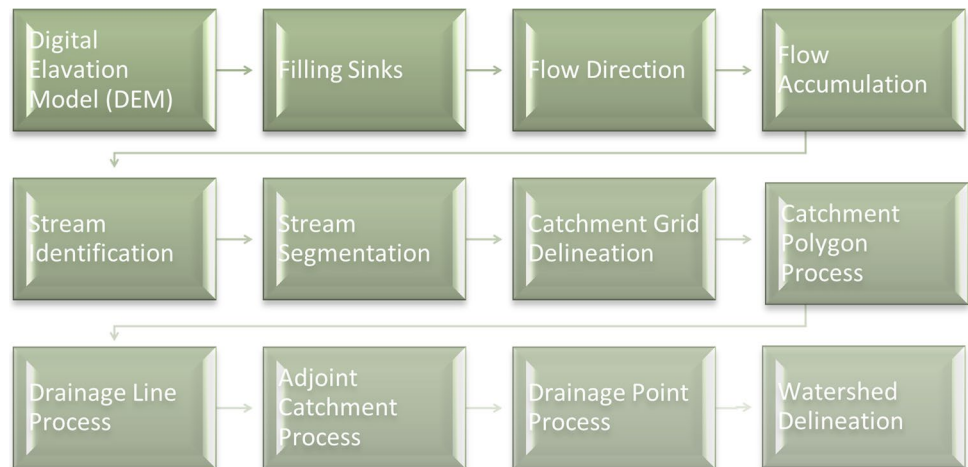


Fig. 4 Aspect map of the Eastern Mediterranean Basin

Fig. 5 Flow chart of watershed delineation process



European Environment Agency. The designated sub-land use classes were overlapped with provincial, district, and neighborhood centers. Then, settlements that should be considered in the preliminary flood risk assessment were determined. Location information of the territories for the provincial center, district centers, neighborhood, and village centers obtained from the CORINE map was evaluated together with

Google Earth bases. Since the CORINE map was prepared in 2012, the boundaries of all provincial and district centers were revised and arranged using the current map bases.

We found that the polygons obtained from CORINE 2012 data did not include all of the current settlement areas in the Eastern Mediterranean Basin. Since the basin is generally composed of mountainous zones, the settlements are

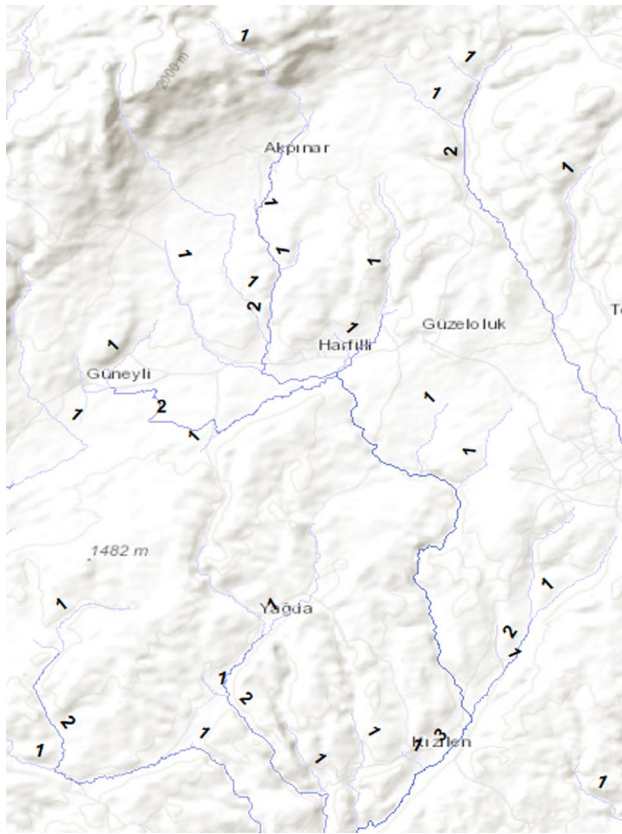


Fig. 6 Ordering with the Horton-Strahler method

distributed dispersedly. Therefore, more settlements than polygons given in the CORINE 2012 data were identified. In this respect, based on Google Earth and raster topographic maps, new settlements were added to the calculations.

A numerical lithology map of the Eastern Mediterranean Basin prepared by the Mineral Research and Exploration Institute (MTA) was examined. The alluvial units in the examined lithological units were separated from other lithological units in the GIS environment, and an alluvial basin map was formed for the region. Subsequently, this base was added to the GIS bases as a separate layer to use in further flood risk determination studies (for superimposing with settlements).

Using the data obtained, previous flood events in the basin were determined. The 'flood areas' layer was superimposed with the 'settlements' layer and used to determine settlements at risk of flooding. Six different classes of stream tributaries were obtained in the Eastern Mediterranean Basin by the Horton-Strahler method. The potential flood areas were examined by relatively increasing the water level of 3 of these stream tributaries by 1.5 m. Streambed data in linear format was converted to point data; height values were defined for the point data obtained using the digital elevation model of the basin. The obtained height information was increased by 1.5 m for each tributary and Thiessen polygons were formed accordingly. With Thiessen polygons, a digital water surface area was created at the same elevation. By overlaying the water surface model on the land topography, potential water spreading areas, which might occur if the

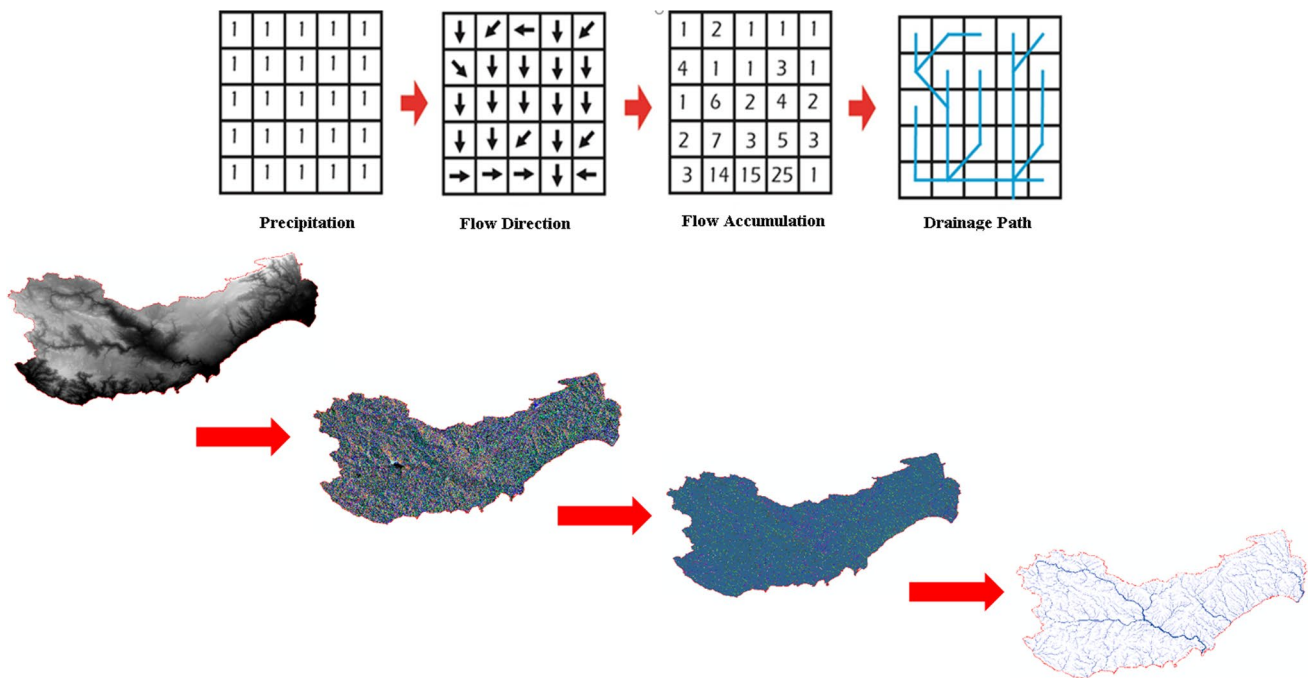


Fig. 7 Flow chart for obtaining the streams

stream water level rise by 1.5 m, were estimated. Regions with economic importance such as residential areas and industrial areas, which were likely to be affected by a 1.5 m of water level rise, were determined, and listed in tables.

The methodology explained above was applied to the drainage waters in the basin. The flood-prone residential areas determined in the basin are marked in Fig. 8.

Results and discussion

In the study, flood risk in the Eastern Mediterranean Basin was examined and 826 settlements were evaluated (Table 1).

In the GIS environment, the polygons used in this study were superimposed on the alluvial sediment layer in the geological map prepared by Mineral Research and Exploration Institute (MTA).

To apply the water-raising method, the classification of the Eastern Mediterranean Basin's stream tributaries was made. With the analysis conducted using the Horton-Strahler method, six different stream classes were obtained in the basin. The flood risk in the settlements was evaluated considering a raise in the water level by 1.5 m in 3 stream tributaries. Settlement areas and other areas that were found to be at high flood risk after the water level rose were also

superimposed on the basin topography using GIS. After these procedures, the results obtained were added to Table 1.

In this study, 826 locations were individually evaluated and flood hazard was determined for each location. During these evaluations, the presence of a flood control facility on the stream causing the flood, existing water storage facilities (dam, pond, etc.), the status of settlements according to alluvial site assessments and the water-raising method, past flood event information, and population of the settlements were examined and some conclusions were made.

As a result of land surveys and these evaluations, we determined the regions at risk of flooding. A list of places deemed risky and determined to be examined by further analyses using hydraulic modeling was given in Table 1. 157 of the 826 settlements examined in the Eastern Mediterranean Basin were found at risk of flood. 59 of these 157 risky settlements were found to have a flood hazard because of the past flood events, 18 of them according to the results of the Horton Strahler ordering, five of them fall within the scope of law 4373, 34 of them due to alluvial area criteria, and 41 of them had several of these criteria.

Since the largest drainage area in the examined basin belongs to the Goksu River, the zones with higher flood risk were mostly found to be on the Goksu riverbanks. The oldest flood record was found in the Göksu River in 1910.



Fig. 8 Flood hazard map of the basin

Goksu stream 22 times in different regions and after that, the most repeated flood record was Deliçay with 5.

We determined that the settlements with higher flood hazards are concentrated in the regions with the rapid slope change and near the river mouth on the shore. The main reason for this finding is that the basin slope and river junction points are important parameters for flood-prone areas according to the methodology used in this study.

In the present study, an evaluation was made for the basin using the main characteristics, the hydrological and meteorological data, the topographic condition, the physical drainage characteristics and the current land use (existing water structures and similar facilities in the basin, agriculture, forest, residential areas, organized industrial districts, etc.), the protected areas, the geological structure, the soil structure, the vegetation, the erosion status, the socio-economic situation, and the information about the past flood events in the basin. All this information is needed in order to propose solutions in the short term about the flood risk areas. Although it is not the subject of this study, it is important in terms of forming a base for the studies to be done.

To summarize; in addition to places of strategic, commercial or economic importance, the settlements in the basin where people live were added to the table, which consists of 17 columns and 826 lines. Historically, places with previous flood records were marked. Alluvial areas were marked. 1.5 m of water was raised to the stream obtained by the Horton Strahler method. Added 5 regions to be protected by law. 157 places, which were obtained by overlapping all the substrates, were determined as places at risk of flooding with a preliminary assessment.

Correctly making CORINE and GIS values of map measurements is the most important reason that increases the accuracy of the flood risk preliminary report. It is believed that the risky places determined by this preliminary assessment could provide a valuable basis for the hydraulic and hydrological models that will be further prepared. For flood risk analysis using random variables and climate-dependent parameters, validation of such a preliminary study with GIS can make an important contribution. This method, which has the opportunity to make a quick preliminary assessment with the data to be obtained from public institutions in a short time, can be easily used in any region of the world.

The Western Mediterranean region basin has a different morphology. The effect of climate change in the Mediterranean is, of course, also seen in the western part. Several studies conducted in the Mediterranean region have analyzed precipitation time series trends and demonstrated ambiguous results. Most of these studies revealed a stationary precipitation trend, while few of them showed upward as well as downward, trends of precipitation; however, in a few studies, these trends were found to be statistically significant (Stathi et al. 2023a, b; Aalijahan et al. 2023; Todaro et al.

2022). Several studies in the Mediterranean region have also revealed a statistically significant increase in air temperature in recent decades (Stathi et al. 2023a, b; Mersin et al. 2022; Philandras et al. 2011).

Studies conducted for this region also show that there are flash flood risks (Bayrakdar et al. 2020).

In the study investigated for the same region in 2021 (Koçyiğit et al. 2021), the flash flood potential of the basin was examined, and a general risk was detected. In this study, risk points were examined in detail and identified point by point. In addition, the water raising-method was used in this study. Besides, the basin geology, which was recommended in the previous study, was also examined. Population information and the status of dams and wetlands in the region were also evaluated in this study. In addition, the fact that the Mediterranean region is the region that will be most affected by climate change explains the increased risk of flash floods. Changes in the topography of the land over time should also be taken into account.

Conclusions

In many regions of the world, there is no accurate data that rely on long-term measurements. It is important to identify and reduce flood risks in the residential areas using the latest data to protect against more flood events due to climate change. In the current study, using the data and archival records obtained from public institutions, flood-prone risk areas were determined without the need for long-term climate modeling or without making a basin-based flood modeling in which too many parameters should be involved. This study was intended to be a preliminary study that local administrators or central government can consider while governing and planning the city. Since it provides a numerical base suitable for many flood modeling programs on the market, this method is considered a holistic approach in which archival records, population trends, and land characteristics are examined together. Using the methodology presented in this study, potential flood risk can be predicted even if there is inadequate data. This methodology can also be used to generate practical and rapid information from a large-scale basin for decision-makers.

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Author contributions 1 did all parts and 1 wrote all sections

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Data availability Data of this study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The author declares no conflict of interest.

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