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A GIS-Based investigation of the causes of the flood disaster in the city center of Şanlıurfa (Türkiye) in 2023

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Abstract

Flood events have occurred frequently in various periods in Şanlıurfa (Türkiye). There were 83 floods between 1950 and 2018 within the borders of Şanlıurfa and most of these floods also affected the city centre. The most recent flood in the city centre of Şanlıurfa took place on March 15, 2023, and 16 people lost their lives in this disaster. In addition, 27 residential buildings, 234 workplaces, 19 schools, 8 mosques and 3 underpasses were damaged in 1978 neighbourhoods. In this study, it is aimed to investigate the causes of the flood disaster in Şanlıurfa' (Türkiye) downtown based on GIS. For this purpose, the natural factors (precipitation, slope, lithology, soil) and human factors (structuring in the stream beds, intervention in the stream bed) that have an effect on the flood have been determined and mapped using GIS-based software. Each factor has been evaluated in terms of floods turning into disasters. The flood event in the study area was caused by various natural factors such as slope, soil characteristics, lithological features and weakness of vegetation, especially due to excessive and sudden downpours. Human factors (construction in the floodplain of Karakoyun, Cavsak, and Karaköprü streams) were effective in the event's becoming a disaster.

1. Introduction

Floods are ranked right after mass movements in the list of disasters causing loss of life and property in Türkiye (Dölek 2021). Flood is a natural hazard that easily turns into a disaster and causes great loss of property and life in Türkiye as it is almost everywhere in the world (Özcan, 2006). In recent years, developments in GIS have facilitated the analysis and management of data related to disasters (earthquakes, landslides, floods, etc.) and the modelling of these data (Bingöl 2023).

Şanlıurfa's downtown is located in the Middle Euphrates Section of the Southeastern Anatolia Region of Türkiye. In this study, the Karakoyun, Cavsak and Karaköprü basins, where floods occur in the city centre of Şanlıurfa, are considered. The study area is surrounded by certain units, Germüş plateau in the north, Tektek plateau in the southeast, Harran plain in the south, and Fatik plateau in the southwest and west. Due to the aforementioned plateaus, the study area is located in a low position relative to its surroundings. According to this, the flow directions of the rivers belonging to the three basins in the study (Karakoyun, Cavsak, and Karaköprü streams) are from the plateaus towards the downtown (Figure 2).

Şanlıurfa has a continental Mediterranean climate in which the summers are hot and dry and the winters are cold. Most precipitation falls in winter and spring. As it is known, precipitation in a short time and in a heavy manner plays the biggest role in the occurrence of flood disasters (Koçman et al. 1996). In areas with an arid-semi-arid climate, such as the research area, too much precipitation variability can trigger ecological and economic losses. (Sepetçioğlu, 2013). As a matter of fact, this has a great role in flooding. In the study area, while slope, lithology, and plant and soil characteristics are the preparatory factors in the formation of floods, meteorological factors enable floods to occur. Human factors come to the fore in the disaster of floods.

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2. Method

In the research, first of all, a literature review was conducted. Subsequently, the preparatory and triggering parameters that are effective in the occurrence of floods were determined and mapped with the relevant literature and field observations. The ArcMap interface of ArcGIS software was used to create these maps. In this study, flow direction, flow accumulation, flow class, drainage network, basin and sub-basin boundaries of the basins were determined by using Raster (cellular) based Digital Elevation Model (DEM) through ArcGIS software. Stream bifurcation values were determined using the Strahler method.

By using the buffer method, areas 50 and 100 meters away, which are considered to be dangerous areas in terms of flooding, were determined as buffer zones. In addition, NDVI (Normalised Difference Vegetation Index) map was produced to reveal the relationship between the vegetation cover in the study area and floods.

A slope map was produced from the digital elevation model. The geological map from MTA(general directorate of mineral research and exploration) and the soil map from OGM(Forest management) were digitized in the ArcMap interface in accordance with the purpose. Afterwards, the areas affected by the disaster that occurred on 15 March 2023 and the spatial distribution of those who lost their lives were determined and associated with.

3. Findings

On 15 March 2023, a flood disaster occurred in Şanlıurfa downtown. As a result of the flood 16 people lost their lives and 1978 houses, 234 business places, 19 schools, 8 mosques and 3 underpasses were damaged in 27 neighbourhoods. Figure 1 shows the areas where flooding occurred on this date. The flooding occurred in Karakoyun stream (Süleymaniye neighbourhood, Piazza, Balıklıgöl surroundings, areas where there is construction in Mance stream, Halepli garden), certain parts of Cavsak stream (Abide junction and its surroundings) and Karaköprü stream (Şenevler and Atakent neighbourhood) (Figure 2.).

The flood disaster that occurred in Şanlıurfa downtown was caused by natural environment features such as precipitation, slope, lithology, and soil and human factors such as construction in stream beds and interventions to the stream bed. The factors that are effective in the formation of flood are examined below.

3.1. Precipitation

Although the average annual precipitation in the downtown is 460 mm, the total amount of precipitation on 15-16 March when the disaster occurred was 146.8 mm (On 15 March 119 mm). Considering that the average annual precipitation amount in March at the research site is 68.3 mm (Figure 3) it is clearly seen that there is extreme rainfall in the field. For this reason, a flood event occurred at the study site and led to a disaster.

Figure 1. Overflow of stream beds in the study area (Karakoyun Stream)

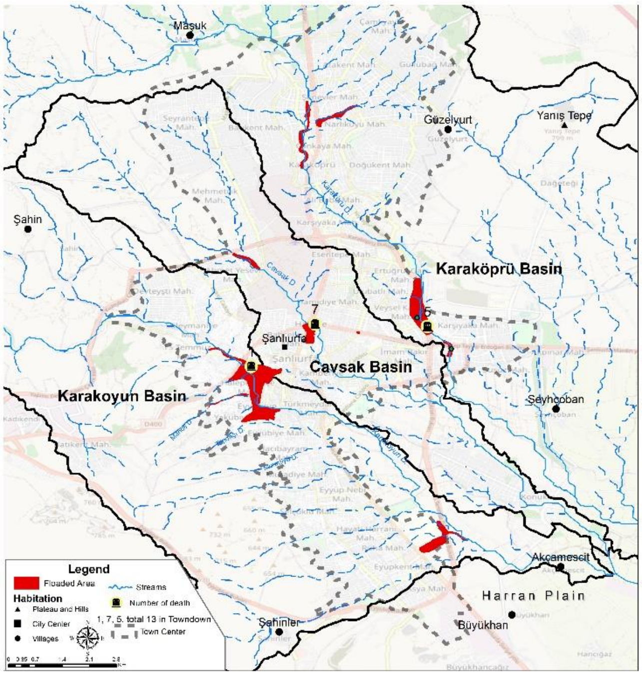

Figure 2. The areas most affected by flooding 2023

Table 1. Total daily Precipitation(m) in Şanlıurfa during the week of the flood (March 2023) (MGM 2023)

Days	11	12	13	14	15	16	17
Precipitation	0	0	1,2	0,6	119	27,8	0,6

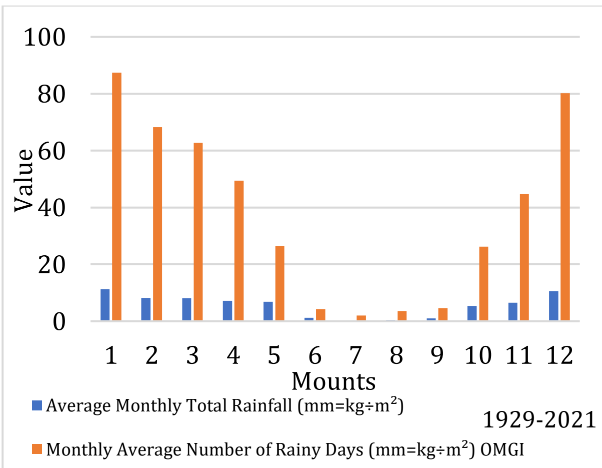

Figure 3. Precipitation (mm) graph of the study area

3.2. Slope

Slope values are an important land parameter in the evaluation of flood potential. According to the results in the literature, water collection basins are evaluated in 4 groups. Areas with slope values less than 2° have a very high potential for flooding. Generally, flat areas with low slopes are temporary water accumulation areas where surface runoff reaches a steady level (Selçuk et al., 2016). Areas with slope values between 2° and 6° have a high flood potential but a lower potential than the first group. These two slope groups cover large areas in the downtown where the flood disaster occurred (Figure 4.). The flood potential of these areas is high. While the slope values are between 6° and 16°, the flood potential is low, and slope values higher than 16° are not significant in terms of flood potential (Masoudian 2009). These classes constitute the upper level of the river basins. Due to the high slope values of these areas, precipitation is directly drained. Therefore, they have low flood potential. However, these slope groups increase the flood potential in the middle and lower reaches of the basins by providing a rapid flow of water towards the lower basins.

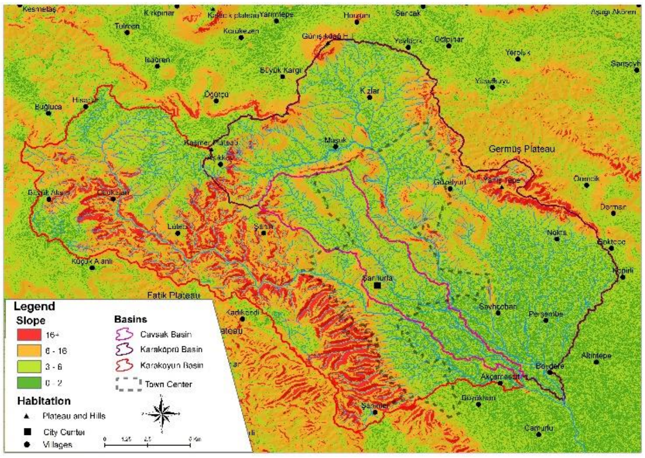

Figure 4. Slope map of the study area

3.3 Lithology

Lithology is an important factor because it affects surface flow. Especially in areas dominated by permeable rocks, water finds the opportunity to seep underground faster. In areas where the permeability property is dominated by less or impermeable rocks, the waters find little or no opportunity to penetrate underground (Şahinalp 2007). It is observed that carbonate rocks (Gaziantep and Fırat Formations) are dominant in the areas where the flood occurred (upper parts of the basin). The fact that there are many north-south and northwest-southeast oriented faults and cracks in these limestones (Kaylı 2020) shows that the permeability is high. However, the existence of limestone levels with high clay content in the solid limestones belonging to both the Gaziantep and Euphrates formations (Kaylı et al. 2022), causes the water to be unable to go deeper. And, on this occasion, the upper levels of the formations are saturated with water faster. In addition, the limestone crust formations that occur in certain parts of the Gaziantep formation also have a negative impact on the transfer of water underground. Especially the limestone shell formations formed by recrystallization form a hard shell on the Gaziantep formation. This situation has caused a decrease in permeability by disconnecting the water from the underground cracks. The above-mentioned features played an important role in causing floods in the middle and lower levels.

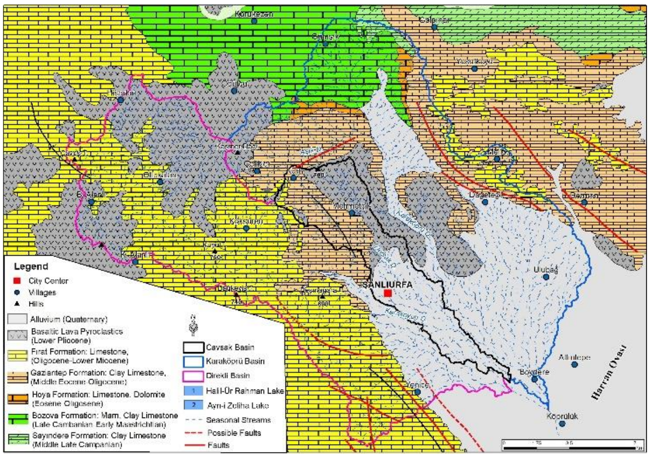

Figure 5. Geology map of the study area

3.4. Vegetation

It has a significant effect on flood formation by increasing the infiltration capacity of water into the soil and protecting the soil cover. The retention of falling precipitation through branches and leaves delays the infiltration of water to the ground. In this respect, vegetation plays a preventive role in the occurrence of floods. It is not possible to mention a significant vegetation cover that can prevent flooding in the study area. The upper reaches of the basins generally have a low plant density index of -0.13-0.09. The upper level of the basins where the flood occurred and the poor vegetation cover in the areas where it was effective increased the severity of the floods.

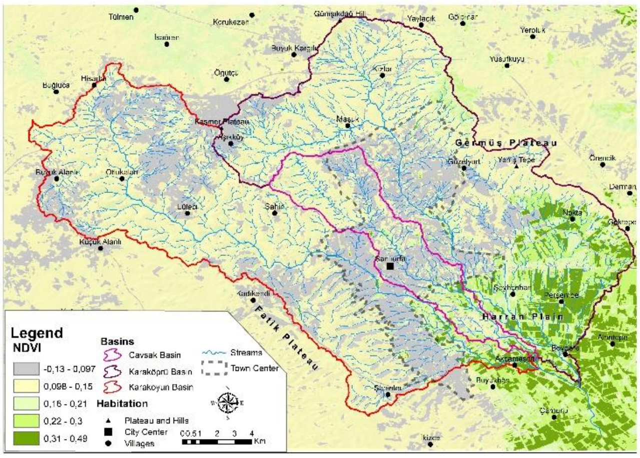

Figure 6. Landsat Normalized Difference Vegetation Index (NDVI) of Study Area

3.5. Soil

Soil structure and texture are important for the formation of floods. In general, brown and reddish-brown soils cover a large area in the study area. Besides, colluvial soils and basaltic soils also can be seen. The clay content of the soils in the field is high. Soils with a high clay content become saturated with water in a short time, causing superficial runoff. The thickness of the soil is an important factor in terms of water infiltration. However, the fact that there is shallow soil on the upper floors and the city centre lacks soil as a result of concreting increases the potential for flooding and flooding by accelerating the surface flow.

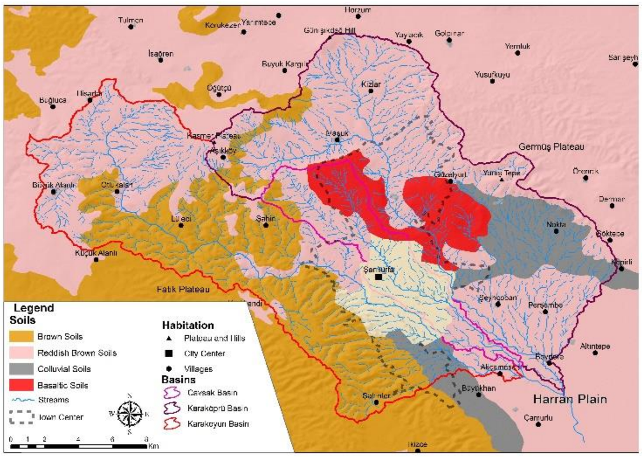

Figure 7. Soil map of the study area

3.6. Construction and intervention in stream beds

The distance to the stream beds is an important factor, especially in terms of flooding. Because the most affected areas in flood events occurring in residential areas are those close to the stream beds (Weli and Oye 2014). Human activities in stream beds cause possible floods to turn into disasters due to the alteration of the stream bed. Urbanization typically increases the amount of surface water and water to be discharged (Selçuk et al. 2016).

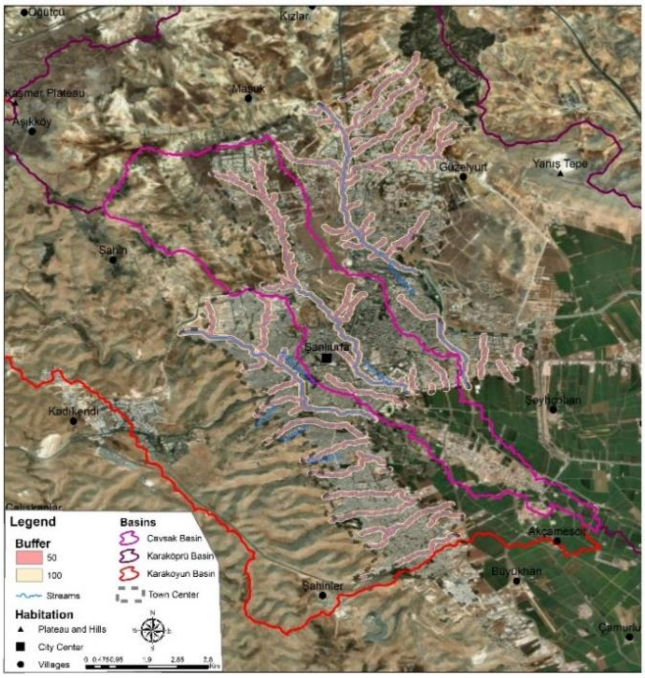

Figure 8. Buffer Map of Stream Beds

There is serious construction in the floodplains of Karakoyun, Cavsak and Karaköprü streams (Figure 8). Especially in some areas, interventions such as narrowing the stream beds and creating closed channel systems, smoothing the stream bed under the heading of riverbed reclamation, unplanned construction (squatting) and conversion of stream beds into streets by covering them with asphalt or concrete have converted flood events into natural hazards.

4. Conclusion

Firstly, excessive rains on March 15-16, 2023 caused flooding in the city of Şanlıurfa, and various natural factors such as slope features, lithological features and soil and vegetation weakness had preparatory effects on the realization of this event. In particular, human factors have been effective in the characterization of the flood as disasters. One of these factors is the structuring of the stream beds and the intervention in the stream beds for various reasons is effective.

In order to effectively combat the flood danger and possible disasters faced by the city of Şanlıurfa, a flood action plan should be prepared and possible risk areas should be identified. There is a shanty settlement in the beds of Karakoyun, Cavsak and Karaköprü streams. These areas should be transformed into green areas through urban transformation works.

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