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Flood analysis of Çan (Kocabaş) stream with UAV images

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Abstract

For societies, natural or human-induced events that cause loss of life and property, create social losses, interrupt life and human activities temporarily and indefinitely and affect the region in many ways, are defined as disasters in general terms. Events that are described as natural disasters are generally the results of the cycle of reorganizing the internal balances of nature, and they are called natural disasters when human societies are damaged by this cycle. Earthquakes and floods, which are among the natural disasters, are the two most affecting disasters in our country. Factors such as the geological structure of the land, its slope, the amount of vegetation, human influence and precipitation are effective in the occurrence of floods. When the floods and flood disasters in our country from past to present are examined, it is seen that many material and moral losses have occurred in our country. Accordingly, it is necessary to take various measures in order to prevent a possible flood disaster that may occur. Today, with the development of technology, it is possible to make predictions and take precautions about possible flood disasters by using various software such as HEC-RAS, MIKE HYDRO. In this study, HEC-RAS software was used as the software. Within the scope of the study, photographs of the part of the Biga (Çan) Stream Basin, which includes Çan and Biga districts, passing through Çan district center, were taken by the eEbee X model fixed-wing unmanned aerial vehicle (UAV), these photographs were transformed into 3D models using various evaluation programs and flood analysis was carried out. necessary data have been obtained. Using the geometric and hydrological data obtained for the flood analysis, 3D flood modeling was performed on the numerical elevation and surface models of the Çan (Kocabaş) Stream with HEC-RAS. Finally, using ArcGIS software, 100 and 500 years old flood maps of Çan district were produced with coordinates on digital elevation and surface models.

1. Introduction

Flood is one of the important disasters that should be considered because the water passing over a certain section may overflow over the section over time and cause various damages by spreading to its surroundings [1]. According to statistics, when the loss of life and property caused by disasters in our country is taken into account, flood disaster comes in second place after the earthquake [2]. This shows how dangerous floods are. The land structures of the areas where the floods occur may be damaged as a result of the disaster. The geological and morphological characteristics of these lands may change after the floods, and the vegetation may be damaged. The area covered by the area where the floods occur, various features of this area (slope, soil structure, etc.) are the main factors affecting the size of the floods [3]. When negative interventions from the outside are added to these factors, it is of course inevitable that extremely negative results will emerge. Minimizing the damages caused by floods can be possible with the right precautions and planning. Çan (Kocabaş) Stream and its surroundings, located in the Çan district of the study area, are among the places where precautions should be taken. From time to time, floods have occurred in the district from the past to the present and material damage has occurred. Considering the location of this flood-prone district, its neighbors are Lapseki and Biga districts on the north, Yenice and Bayramiç districts on the south, Çanakkale city center and Yenice districts on the west, while the only neighbor on the east is Yenice district (Figure 1). The Çan (Kocabaş) Stream (Figure 2), which is one of the river basins in the Marmara Sea passing through the district, passes through Çan and Biga districts and empties into the Marmara Sea. The floods experienced on the river from the past to the present have had a significant negative impact on the two districts it passes through due to its geological location. The basin of the stream has a height of up to 1110 m, a perimeter of 266.68 km and a surface area of 2310.74 km^2. During the current period, the water level of the creek rises with the effect of rains that fall from time to time and damages its surroundings. When a literature search was conducted on the previous studies on tea, it was observed that the maximum flow value of the tea was measured in the near future, and according to the results, the severity of the floods caused by the unplanned urbanization and faulty land use in the tea bed was observed [4]. The most recent floods occurred in both Çan and Biga districts on the river in February 2022.

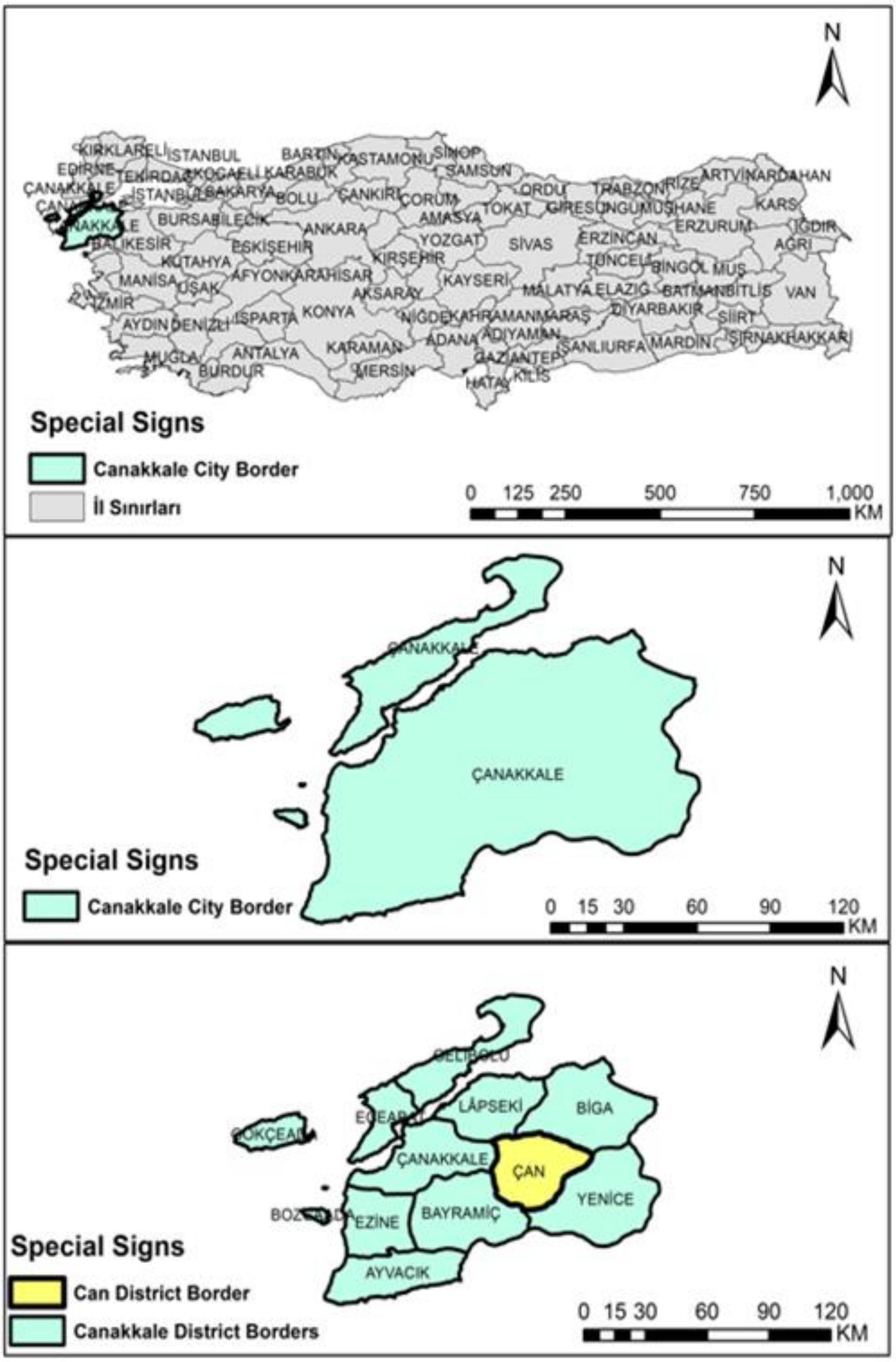

Figure 1. District settlement map

Figure 2. Can (Kocabas) Stream

Considering the experienced flood inventories, the prepared flood hydraulic models and the hydrometric-meteorological observation data, not building at a certain distance from the stream line will help to reduce the flood hazard rate [5]. Various studies have been carried out on floods from past to present. Working people made predictions and suggestions about floods using software such as HEC-RAS, MIKE HYDRO.

Contributing to the flood risk analysis of the streams in the Black Sea Region, Dolo obtained the flood spread maps of the Arhavi district by processing the photographs it obtained as a result of the drone data in the study it carried out in 2018. He also used the HEC-RAS program to create the flood propagation map and created flood-flood models for recurrence periods of 2, 5, 10, 25, 50 and 100 years. Accordingly, it has been determined that 101.30mm, 120.36mm, 152.11mm, 247.38mm, 406.15mm and 723.70mm precipitation may occur for every 24 hours. In addition, the water level change of the study area was observed with these precipitations. As a result of the analysis, it was understood that there are factors that negatively affect the flow of water and that necessary precautions should be taken [6]. Another study on floods was made by Kuşoğlu. Kuşoğlu, in his study in 2019, firstly talked about the effects of the flood disaster on the world and our country, and determined the Törbüzek Stream, located in the Göksun district of Kahramanmaraş, as the study area. He digitized the data of the study area with AutoCad Civil 3D program and defined the stream route and cross-sections with the help of the program. These geometric data were entered into the HEC-RAS software for analysis and 100 and 500 years of flood spread maps of the Törbüzek Stream were created. According to the results of the analysis, it has been understood that the area of approximately 3000 decares carries a flood risk [7]. Cantürk, who carried out his work in 2022, carried out a study on the collapse and flood spreads of rainy and sunny days for Kirazlı, Çiftlik Dere and Bekir Cevdet Dündar Ponds in Yozgat. Cantürk, who used MIKE FLOOD software for hydrodynamic analysis in the study, produced flood hazard maps and analyzed whether the culverts in the ponds are necessary for the floods in the possible scenario. As a result of the analysis, it has been observed that the closed creek sections and outlet culverts will be insufficient against floods and the D200 highway and underpass passing through the city will be flooded in case of possible predictions [8].

In the study inspired by this and similar studies, the flood analysis of the section of Kocabaş Stream, which has caused floods from the past to the present, passing through the Çan district center, was carried out using Hec-Ras software. In the study, first of all, aerial photographs of Çan district center, which constitutes the working area, were taken with a fixed-wing aircraft (eBee X) via autopilot software (eMotion), then various products of the city such as 3D point cloud, DSM and orthophoto were created with Pix4dMapper, these products are Virtual Surveyor 7 and DSM and DEM were produced by editing with programs such as ArcGIS 10.5 and it was the source of the Hec-Ras 6.1 program in which flood analysis was made. Various flood analyzes such as 100 years and 500 years of Çan district center were carried out using the geometric data produced and the hydrological data (flow rate and roughness values) obtained from the institutions, and the results between DSM and DSM were examined. In the study, the differences between the models were also examined by testing different roughness values and the importance of improvement studies was emphasized accordingly.

2. Material and Method

Since the eEbee X model Unmanned Aerial Vehicle (UAV) used in the field studies part of the study has PPK (Post Process Kinematic) feature, without the need to create a ground control point before the flight with the help of a GNSS (Global Navigation Satellite Systems) receiver with static data recording capacity, coordinated aerial photos were taken. UAV, one of the data collection tools adopted in recent years, was preferred to collect the required image data [9]. UAVs provide instantaneous data production and imaging, quick data analysis and, depending on this, time and cost saving [10]. UAV is a very beneficial tool to obtain information without touching the object [11].

2.1. Tools and data

Within the scope of the study, a flight planning was made using autopilot application (Emotions) for the region where the flight will be performed. In this context, the approximate elevations of the area where the flight will be made were examined on Google Earth, the study area was divided into 5 flight zones, the altitude required for the flight (220.8 m) and the transverse and longitudinal overlap ratios (60-80%) were determined and these values were entered into the application (Table 1).

The photographs needed for model production in the study were taken with the eEbee X model UAV with PPK feature. Real-time data transmission is not required with the GNSS receiver (or 1 second Rinex data of TUSAGA-AKTİF stations can also be used) installed at a known point during the flight in UAVs with PPK feature. Therefore, there is no problem in data communication between the GNSS receiver and the UAV. For the use of this method, it is necessary to use a GNSS receiver that can make static measurements. During the flight, both the UAV and the GNSS receiver record the satellite observation data. In this way, after the work in the field is completed, the data obtained by using the evaluation software are processed and as a result, high precision and accuracy final products are obtained. In the PPK method, there is no need for a connection between the UAV and the GNSS receiver, the flight planning is short, the data solution is reliable, and the TUSAGA ACTIVE station data are among the advantages of the method.

The technical specifications of the PPK-capable UAV used in the study are as follows (Table 2).

Table 1. Flight information

Flight Number	Overlay Rates (W-L)	Flight Altitude (m)	Flight Time (min)	Number of Photos	Range (ha)
1	%60-%80	220.8 m	70.28 min	1170	376.70 ha
2	%60-%80	220.8 m	17.14 min	226	54.30 ha
3	%60-%80	220.8 m	49.28 min	783	241.10 ha
4	%60-%80	220.8 m	54.57 min	917	300.20 ha
5	%60-%80	220.8 m	38.25 min	599	187.00 ha

Table 2. Technical characteristics of the UAV

Characteristics	Values
Maximum weight / Wingspan	1.7 kg/116 cm
Cruising speed	Max 110 m/sn
Maximum flight time	Max 90 min
Photo quality	24 MP
PPK/RTK feature	+
Satellite positioning systems feature	+
Radiolink distance	3 km

In the office part, which is the second stage of the study, a 3D model of the photographs taken with the UAV was obtained by means of Pix4dmapper, a 3D model generation software. Necessary definitions were made in the software before model production and the TUREF/TM27 coordinate system was chosen as the output coordinate and the Turkish National Reference Frame was chosen as the datum. Since the photographs taken were produced in a coordinated manner, the process steps were passed without entering the ground control points (YKN) in the software. In the Pix4dmapper software, the first processing step is creating a sparse point cloud, the second processing step is creating a dense point cloud, and the final processing step is DSM and orthophoto production. As mentioned here, the processing steps were carried out and the output products (3D model, DSM, orthophoto) were obtained.

The mean square error (RMSE) values of the model of the study area produced with the Pix4dmapper software are as follows (Table 3). According to the report, the mean squared errors in the x, y and z directions were calculated as 4.9 cm, 1.6 cm and 2.7 cm, respectively.

Table 3. Square mean errors

Min Error [m]	Max Error [m]	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-6.72	0	0	0
-6.72	-5.37	0	0	0
-5.37	-4.03	0	0	0
-4.03	-2.69	0	0	0
-2.69	-1.34	0	0	0
-1.34	0	49.03	49.03	49.73
0	1.34	50.97	50.97	50.27
1.34	2.69	0	0	0
2.69	4.03	0	0	0
4.03	5.37	0	0	0
5.37	6.72	0	0	0
6.72	-	0	0	0
Mean [m]		-0.00445	0.000222	-0.00145
Sigma [m]		0.049021	0.015911	0.027214
RMS Error [m]		0.049223	0.015913	0.027253

ArcMap software was used in the first place to perform the flood analysis, which is the main subject of the study. A database has been prepared for Hec Ras, the software to be used for flood simulation, using both DEM and DSM in the software. ArcMap Kocabaş Stream of approximately 2.5 km route (river) was drawn, the left and right banks of the brook (bank lines) were drawn, and finally, 51 cut lines, approximately 2 km long at regular intervals, perpendicular to the brook route. process was performed (Figure 3,4). With the drawn cross-sections, the equivalents of the places where the lines pass were obtained. These process steps were made for both the digital surface model (DSM) and the digital elevation model (DEM) and Hec-Ras software, which is the software for the last part of the study, was used.

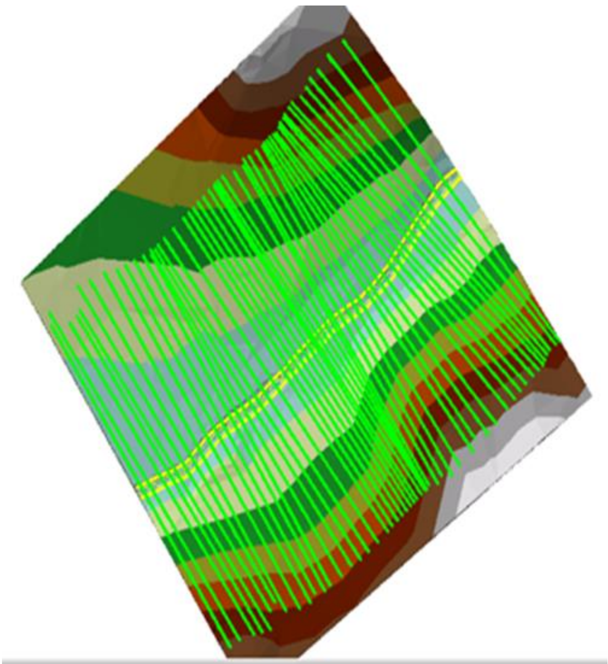

Figure 3. Drawing cross section for DEM

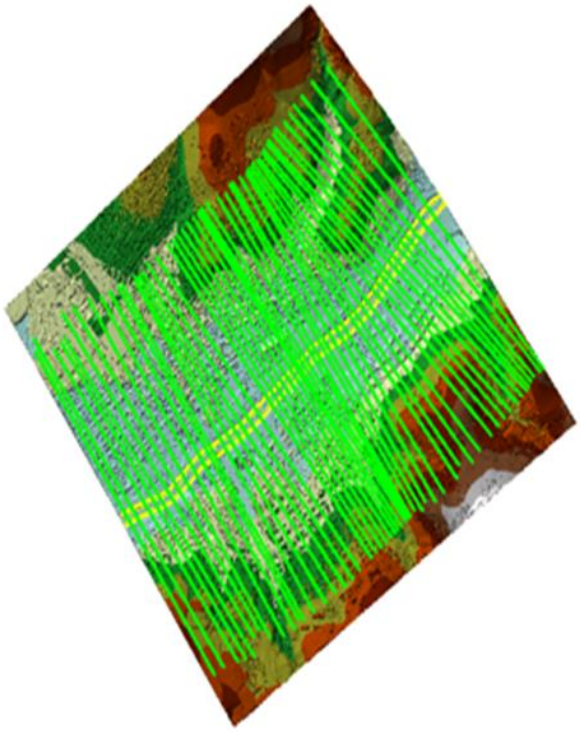

Figure 4. Drawing cross section for DSM

HEC-RAS is an open channel and flood analysis program developed by USACE (US Army Engineering Association) and offered to users free of charge. The integrated working feature of HEC-RAS with Arc-GIS enables many disciplines in different professions to use the program and make analyzes. With the corrections and improvements made on the program over time, users were given the opportunity to perform 2D analysis. In 1D analysis, analysis can be made along the cross-sections drawn, that is, where there are no cross-sections, the analysis cannot be done by the program. In 2D analysis, on the other hand, grid mesh system in various sizes can be defined with the program and analyzes can be made more easily. With HEC-RAS, one-dimensional regular flow, irregular flow, sediment transport and water quality modeling can be performed [12]. Thanks to the feature in the new versions of HEC-RAS, it is possible to see the 3D view of the analyzes made by using the RAS Mapper tab in the program. With the program, it is possible to reach results such as flood spread area, water depth, flow velocity.

In order to be able to analyze in the program, geometric and hydrological data sources must be ready. While the geometric data of the study were obtained with Pix4d Mapper and ArcGIS programs, the flow and roughness values, which are hydrological data, were obtained from the 252nd Branch of DS.

The manning roughness coefficient, which is needed for analysis in flood analysis, is the coefficient that determines the factors that can affect the flow rate of water in a stream bed. The Manning roughness coefficient affects the accuracy of flood maps created for study areas. Accordingly, acting according to knowledge and experience while determining this coefficient will affect the studies positively and correctly. While there are many methods to determine the 'n' roughness coefficient, it has been announced by DSI that the Cowan Method is the best method to determine the roughness coefficient in stream beds in our country. The Cowan Method was developed in 1956 by W.L. Invented and developed by Cowan.

The Cowan Method (Table 4), which was developed by the DSI flood expert commission and allows to find the roughness coefficient, has the following formula;

n = m.(nb+n1+n2+n3+n4) Here;
n= Manning Roughness Coefficient
m= Degree of Channel Fold
nb=Type of mattress material
n1= Channel slope status
n2= Change in section of the channel
n3= The effect of obstacles in the channel (pool, mound, culvert, etc.)
n4= refers to the vegetation in the channel.

Table 4. Modified Cowan method roughness coefficient table

Type of material on the river bed	Concrete		--	nb	0,012-0,018
	Rock		--		--
	Soil		--		0,025-0,032
	Grit		1-2		0,026-0,035
	Fine Gravel	Median diameter(mm)	--		--
	Gravel		2.64		0,028-0,035
	Coarse Gravel		--		--
	Coarse stone		64-256		0,030-0,050
	Big Rock		>256		0,040-0,070
Channel side slope	Smooth			n1	0,000
	Insignificant	Concrete wall			0,003
		Stone wall			0,005
	Middle	Stacking stone support			0,008
		Soil slope			0,010
	Severe	Stacked stone support			0,015
		Tree slope			0,020
Channel section change	Gradual			n2	0,000
	Occasionally changing				0,005
	Frequently changing				0,010-0,015
Obstacles in the channel	Neglected		<%5	n3	0,000
	Insignificant		%5-15		0,010-0,015
	Noteworthy		%15-50		0,020-0,030
	Severe		>%50		0,040-0,060
Vegetation in the channel	Low			n4	0,005-0,010
	Middle				0,010-0,025
	High				0,025-0,050
	Very high				0,050-0,100
Channel fold	Insignificant		1-1,2	n5	1,000
	Noteworthy		1,2-1,5		1,150
	Severe		>1,5		1,300

n=m*(nb+n1+n2+n3+n4) = 1*(0,017+0,003+0+0+0) = 0,020

In the study, the nb value was determined as 0.017, the n1 value was 0.003, the n2 value was 0.000, the n3 value was 0.000, the n4 value was 0.000, and the n5 value was 1.000 by the DSI 252nd Branch Directorate. From here, the roughness value of n is calculated as 0.020 for the stream route, left and right shores. In the study, the n4 value was taken as 0.100 in order to see the importance of the improvement works, the value of 0.12 was used for the creek route, left and right coasts, and the differences between the models were examined. In the study, the recurrent flow rates of 100 and 500 years were determined by DSI and the values determined below are shown in Table 5.

Table 5. Çan (Kocabaş) Stream 100 and 500 year recursive flow rates

KM	Tekerrür	Debi (m^3/sn)
0+000.00- 2+577.53	Q100 Q500	711.60 957.90

In order to carry out the flood analysis, 100 and 500 years of flood recurrence rates and Manning roughness coefficients of Çan (Kocabaş) Stream obtained from Çanakkale DSİ 252. Branch Directorate were entered in HEC-RAS for both DSM and DEM, respectively, considering the characteristics of Kocabaş Stream. Stable flow and critical depth as the flow of water, and mixed regime for flow regime were selected in the software and 1D evaluation results were obtained accordingly (Figure 5-8).

In addition to the roughness coefficient value (n=0.02), which was used for the analysis and obtained from DSI, the assumption that the vegetation was dense (n4=0.100 was used) and a different roughness coefficient value (n=0.12) was made to observe the effect of the roughness coefficient on the flood analysis. 100 and 500 years flood depth and spread maps obtained by entering different roughness values on DSM are as shown on the right (Figure 9,10).

When the 100-year flood maps produced using the digital elevation model and the digital surface model are examined (Figure 5,7), it is seen that the depth of the elevation model reaches 5.6 m and the depth of the surface model reaches 6.5 m. When the 500-year-old flood maps produced using the digital elevation model and the digital surface model are examined (Figure 6,8), it is seen that the depth of the elevation model reaches 6.2 m and the depth of the surface model reaches 7.3 m. When the maps produced by testing different roughness coefficients are examined (Figure 9,10), it is seen that the depth amount reached 9.9 m in the 100-year analysis and 11 m in the 500-year analysis.

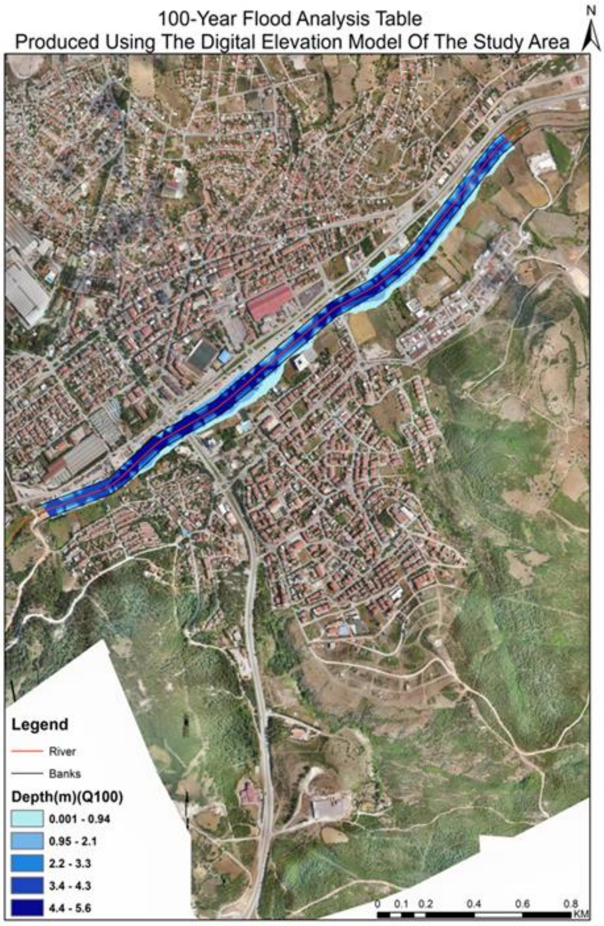

Figure 5. Representation of the 100-year floodplain map on the orthophoto for DEM

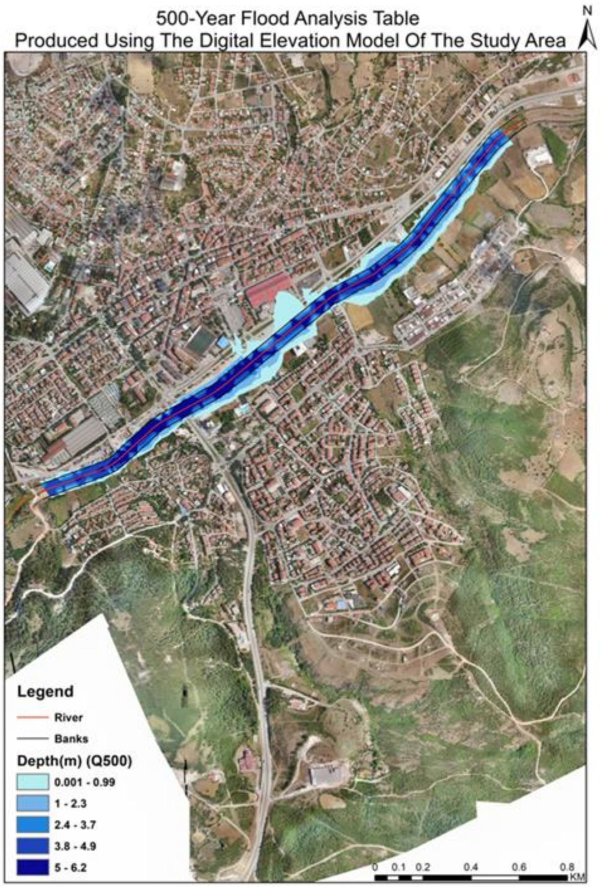

Figure 6. Representation of the 500-year floodplain map on the orthophoto for DEM

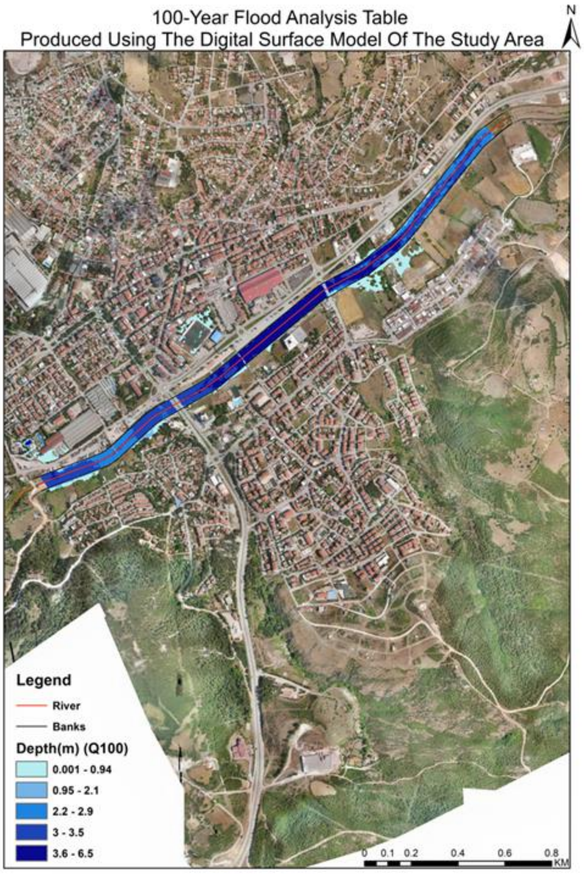

Figure 7. Representation of the 100-year floodplain map on the orthophoto for DSM

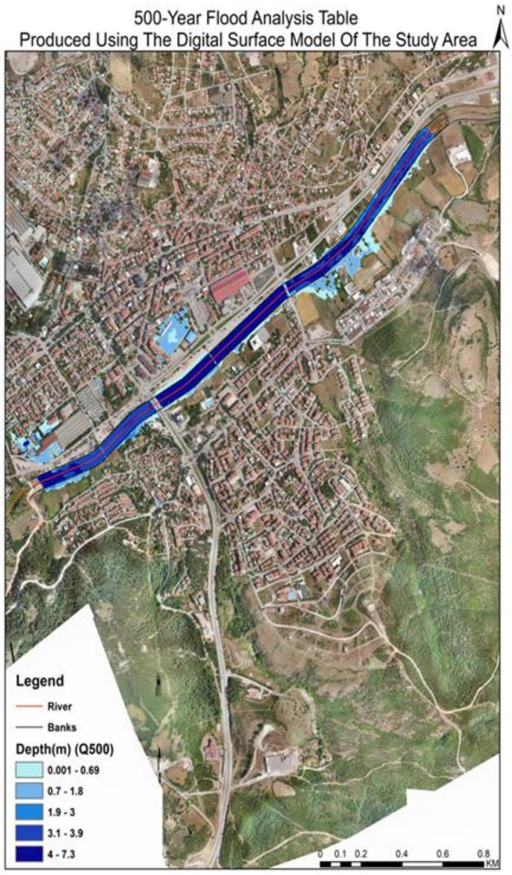

Figure 8. Representation of the 500-year floodplain map on the orthophoto for DSM

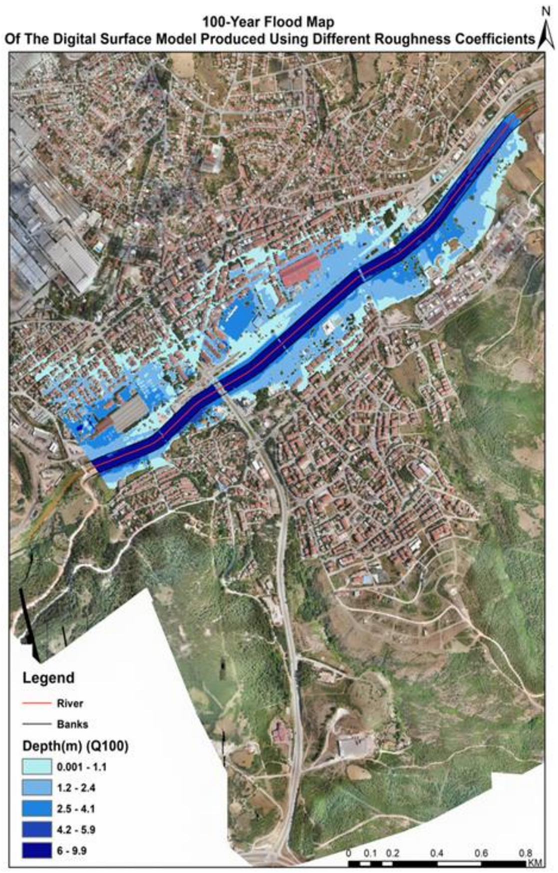

Figure 9. Representation of the 100-year floodplain map on the orthophoto for DSM

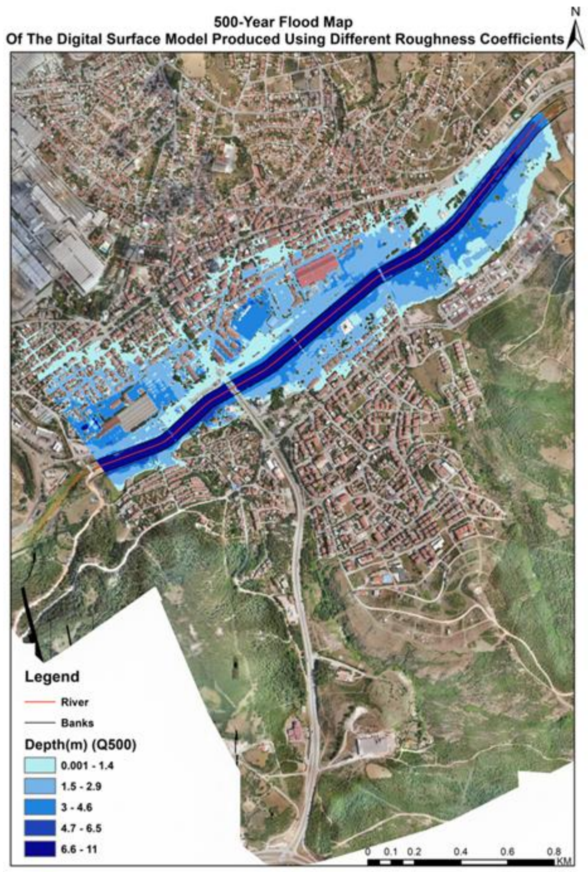

Figure 10. Representation of the 100-year floodplain map on the orthophoto for DSM

3. Results

Türkiye includes different climatic conditions due to its geographical location. It is assumed that there are changes in climatic zones due to global warming [13]. Flood disasters all over the world and second in terms of loss of life and property in Turkey, located between meteorological disasters in the first place [14]. Climate change has a long-term impact on the ecosystem [15]. Climate change studies have an important place in the management of water resources [16]. One of the important causes of climate change is floods. A flood is a natural disaster that causes damage to the surrounding lands, settlements and living creatures by not fitting the amount of water in the riverbed for various reasons [17]. Floods are in the first place among natural disasters in terms of damage to the community and the number of victims [18]. Floods, which have been frequently seen in our country in recent years, have become one of the types of natural disasters that cause significant material and moral losses [19]. The frequency of occurrence of floods and the increase in the affected areas make flood maps, flood research and modeling studies important [20]. Flood studies seek to reduce time and effort for decision makers for flood risk management [21].

Türkiye is frequently exposed to floods, earthquakes, landslides and natural disasters due to its geomorphological features [22]. Water management and flood analysis has become a very important issue today [23].

In the district of Çan, where the subject of this thesis is located, it was observed that the flood risk was experienced with the increasing precipitation in February 2022. Flood analysis of Çan (Kocabaş) Stream passing through Çan district was carried out with the thesis study titled "A flood analysis using UAV images: The sample of Çan (Kocabaş) Stream". In this study, flood models were made using HEC-RAS software according to 100 and 500 years of iterative flood recurrence rates. In the study, flood analyzes were carried out both on the digital elevation model showing the bare structure of the land and on the digital surface model reflecting the real topography of the land, using the flow rate and roughness values obtained from the 252nd Branch Directorate of DSI. As a result of the analyzes made, it has been observed that the 3.7 m high flood protection walls around the Çan (Kocabaş) Stream will not have enough water carrying capacity in possible situations and will cause floods. Especially in the study on the surface model, it was determined as a result of the analyzes that the flood depth and spreading areas showed their effects in more regions. This is thought to be because the factors affecting the flow of water are taken into account when real land topography is used. In this study, the importance of the roughness coefficient used in the analyzes was also wanted to be examined, the vegetation on the tea was thought to be dense, and 100 and 500-year analyzes were made on the surface model using a higher value roughness coefficient value. As a result of this analysis, the effect of the roughness coefficient on the flood analysis was clearly seen. Accordingly, contrary to the previous analyzes obtained from DSI, a significant increase was observed in the flood depth and spreading amounts. As a result of the application, it was determined that the flood area expanded up to 600 m in places and affected many structures. From these results, as a result of all the analyzes made within the scope of the study, it is seen that the flood protection walls will be insufficient against floods in case of realization of possible possibilities.

4. Conclusion

According to the results obtained from the study, some precautions should be taken in the study area. Accordingly, the flood protection walls around the Çan (Kocabaş) Stream should be expanded and raised to meet the analysis. The substances that are/will be thrown into the tea in a way that will affect the flow of the tea from the outside should be cleaned from the tea. In particular, one of the most important problems of the tea and the flood analysis that causes the water to spread over large areas, the vegetation that emerges spontaneously in the tea should be cleaned regularly. The existing zoning plans of the district should be reviewed and construction and usage permits should not be given to areas with flood risk, these areas should be considered as green areas. In addition, an early warning system should be established in the region where the tea passes and measures should be taken in case of a possible flood.

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Author contributions

Sercan İlhan: Data curation, Writing-Original draft preparation, Software, Validation, Field study **Umut Aydar:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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