DOI: 10.24996/ijs.2023.64.7.46

ISSN: 0067-2904

Flood Scenario of Tigris River in Baghdad City

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Received: 4/11/2022 Accepted: 25/2/2023 Published: 30/7/2023

Abstract.
Flooding hazard is an important and dangerous natural phenomenon that leads to significant material losses. It should be studied and scenario to prevent significant losses. The studies should consider the impact of many factors such as human, infrastructure, economic,..etc. The main objective of the research is the risk management procedure. The study was conducted in Baghdad, Iraq. The materials for completing this research were prepared by gathering a satellite image and Digital Elevation Model (DEM) via the USGS website, then processed, analyzed, and converted into a different flood region concerning the probability of rising water levels where the normal height of Baghdad city is 28m over sea level. This scenario defines 3m, 4m, and 5m heights over the Tigris river cliff, which are the possible heights at which the water level may rise above the normal height. The range of the elevations becomes either 31m, 32m, or 33m over sea level. Many software's were conducted in this research, such as MatLab, ArcGIS, and ENVI.

Keywords: Flood, Tigris River, Scenario, Modelling, DEM.

سيناريو فيضان نهر دجلة في مدينة بغداد

عدي حاتم شعبان
قسم التحسس النائي ونظم المعلومات الجغرافية ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

الخلاصة:
تعتبر مخاطر الفيضانات ظاهرة طبيعية مهمة وخطيرة تؤدي إلى خسائر مادية كبيرة، لذلك يجب دراستها وخلق سيناريوهات لمنع الخسائر الكبيرة. يجب أن تأخذ الدراسات في الاعتبار تأثير العديد من العوامل مثل البشرية والبنية التحتية والاقتصادية، ... إلخ. تم اختيار منطقة الدراسة لتكون (مدينة بغداد) والتي كانت الهدف من هذه الدراسة.اعدت المواد اللازمة لإكمال هذا البحث من خلال جمع صورة القمر الصناعي ونموذج الارتفاع الرقمي (DEM) عبر موقع هيئة المسح الجيولوجي الأمريكية(USGS) ، ثم معالجتها وتحليلها وتحويلها إلى مناطق فيضان مختلفة فيما يتعلق باحتمالية ارتفاع منسوب المياه عن الارتفاع الطبيعي. مدينة بغداد على ارتفاع (28 م) عن سطح البحر. يحدد هذا السيناريو (3 م ، 4 م ، 5 م) ارتفاع فوق منحدر نهر دجلة وهي الارتفاعات المحتملة التي قد يرتفع عندها منسوب المياه فوق الارتفاع الطبيعي ويصبح مدى الارتفاعات إما (31 م)، (32 م) و (33 م) فوق مستوى سطح البحر.

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1. Introduction

Risk management is a malty obligation to prevent huge damages from the hazard phenomenon. It is necessary to study the situation of the river, which is an essential factor in analyzing the flow of water, the bottom of the river, water level height, and monitoring the water resources. Without external influence, the river's water level increases the river's height, such as rain, wind, and storms. The water river's height is measured in meters, usually represented by the zero height from the bottom of the river. Affecting a particular river by winds or storms leads to an increase in the height of the river situation. Through this phenomenon, it is essential to analyze some critical points that affect the surrounding areas [1].

A geographic information system (GIS) was used to analyze the data. Many rainfalls at frequent periods and specific seasons affect water levels, especially in rivers. Subsequently, a flood may arise, affecting the surrounding areas. Also, the risks and impacts of collecting the appropriate data, analyzing, and interpreting it using GIS should be known [2].

Flood types are (Flash floods, Coastal floods, Urban floods, River (or fluvial) floods) and Ponding (or pluvial flooding). The flood type that will be investigated in this research is River (or fluvial) floods. The first reason for river flooding is rainfall over an extended period and area, which can cause significant overflow in riverbanks. The lowest area could be affected, even when they did not receive much rain. This will be a different impact depending on river sizes, which is a negative relationship. Rainwater enters the river in many ways, even directly or through the catchment area [3]. The other reason for river flooding is a dam breaking, releasing water suddenly; the strength of this water may carry cars, trees, and even houses away and cause loss of life. In addition, it could damage surrounding river areas. The significant increase in water flow is started by relying on the standard definition (the stage at which overflow of the shore flow begins to cause damage in the local area) [4]. One of the most dangerous natural environmental disasters is floods, which affect the world's population and lead to the loss of people's lives, homes, equipment, and material [5]. The economic losses that affected the areas and housing by the flood led to several crises, including immigration from one area to another.

The population becomes crowded, and most affected people are in the low areas or areas where it reached a wide range [6]. According to Adedeji and Odufuwa (2012), floods caused about half of the disasters worldwide and 84% of worldwide disaster deaths [7]. It is essential to predict flooding by knowing the data necessary or using new emergency techniques to reduce as much as possible from floods. There may be difficulties in data collection and identification, primarily due to insufficient data, where the time factor significantly affects [8] [9]. According to Pan (2012), using satellite imagery and digital elevation model data, river stage, and discharge could provide an alternative to labor-intensive measurements on the ground [10]. This research aims to create a scenario model for flooding effects on Baghdad city caused by the rising water level of the Tigris River.

The digital elevation model (DEM), defined as digital maps, uses two-dimensional measurements for the study area with an elevation dataset [11] [12]. The accuracy of DEMs depends on several factors, including horizontal and vertical accuracy, depending on the resolution of each direction (horizontal or vertical) [13]. Sugumaran (2000) states that DEMs are used more frequently in floodplain management, including examples of plains, simulations, coastal flood risk assessment, and determining the flood plains' height [14] [15]. Flood models are widely used for flood modeling, damage assessment and identification design studies, flood emergency management, and improved flood forecasting. The other way to study the flood model is the DTM, which is different from DEM in presenting the artificial buildings and other instructions for the studied area [16] [17] [18]. The difference in the ground height is usually only a few centimeters in order, and the displacement of the different measurements in the height data significantly impacts the accuracy of the evaluation of the potential risks [19] [20] [21]. In the examples listed above on the applications of the digital elevation model, it is essential to use this method to solve several problems, as well as more accurate 3D maps may be used to learn about different elevations of the terrain and to measure and address them more by applying these tools to the water height level (river stage), and comparing them during the flood.

The geographic information system (GIS) is a framework for gathering, managing, and analyzing data. The most potent tool in GIS is the spatial analysis and spatial modeling that can design many applicable models that help the world understand many problems, reach multiple ways, and make decisions more flexibly and intelligently [22] [23].

2. Study Area

The studied area represents the capital city, Baghdad, of the Republic of Iraq country. Baghdad city is divided into two parts, the first one is Baghdad Mayor (Central city), and the second part is the governorate of Baghdad (outskirts of Baghdad). Baghdad Mayor is located between (44.227^0 to 44.578^0) East and (33.175^0 to 33.507^0) North and on the Tigris River. Figure 1 represents the studied area with a satellite photomap resolution (2 m) from the WorldView-2 satellite. The capital city's population is about 7.5 million people, distributed between Rusafa and Karkh, the two sides of Baghdad over the Tigris River.

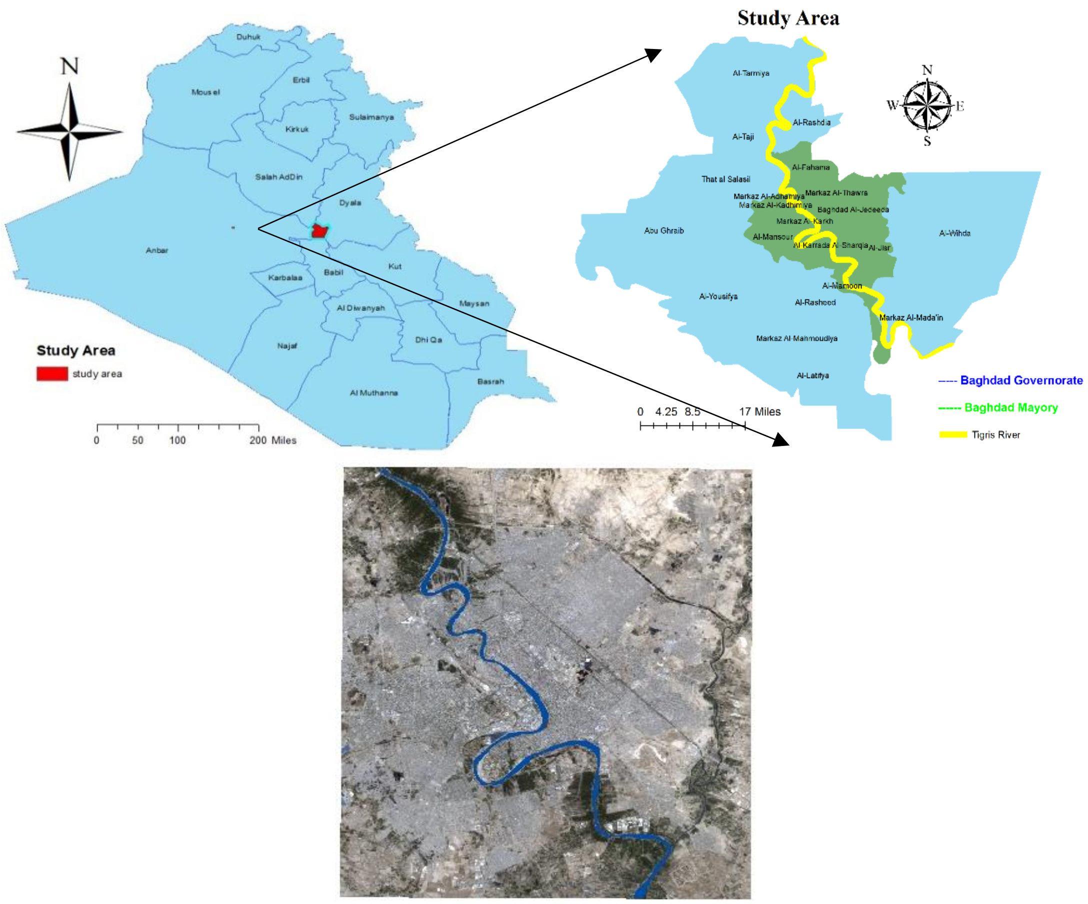

Figure 1: Study area, Baghdad city, Iraq, with satellite photo map.

3. Methodology

The simulation model illustrated the water spreads over the area concerning the height of the terrain and the obstacles the water encounters. The predictions illustrated the water spreads and how high the water will be at each part of the studied area. Some models also make it possible to see other aspects of the flood, like the incoming water's velocity. The DEM (SRTM 1 Arc-Second Global) was downloaded from the (USGS) website. The ArcGIS software was used to process and analyze the satellite image spatially. This project's workspace with all layers used the UTM projection (WGS1984 UTM Zone 38N). After that, many steps were done utilizing ArcMap to compensate for the values of unidentified pixels or pixels that do not contain data. A study area’s shape file was done to clip the satellite image and the entire layers. Figure 2 illustrates the DEM for both sources, STRM and ASTER satellites, for the studied area as a row of data.

Figure 2: Digital Elevation Model (DEM): **a-** (SRTM satellite) **b-** (ASTER satellite) for the study area.

Several steps were taken to extract the results, starting with calculating contour lines with 1 m intervals to build a base map. The contour lines are highly crowded because of using a 1m resolution. The selection of 1m intervals is due to the sensitive changes in water height depending on the morphology of the studied area.

The following steps utilized many pre-processing applications such as clip, georeferencing, and creating shapefiles for each (point, line, and polygon) to reach the goal. Extraction tools were used to remove the areas not included in the research process, reduce the storage space for the model used, and determine the scope of work more focused.

A mathematical operation for the DEM was obtained to see the region's heights and then apply an increase in the height of the water levels according to those areas. This process eliminates the abnormal data from the DEM through statistics, extracts the mentioned height from the image by elimination, and overlays the layers on each other; this process highlights the heights of the regions. The other step is to the height of the water levels according to those areas. The normal height of Baghdad city is equal to 28m, and the poss water levels can be raised. The scenario considers the river water levels rising at 3m, 4m, and 5m above the normal height (28m), which is meant the following height 31m, 32m, and 33m, which is the increase in height according to sea level. A raster calculator was used through spatial analysis for DEM to extract the morphology of the studied area and highlight the height of each point in the area. The process takes more than several steps to redefine the values of the heights, starting with reclassifying applications to extract them more precisely. To facilitate dealing with them, a new conversion will be applied to transfer the height values to a polygon. The goal of this work will appear through the limitation of the flooded area concerning the water level heights. The work procedure can be summarized in Figure 3.

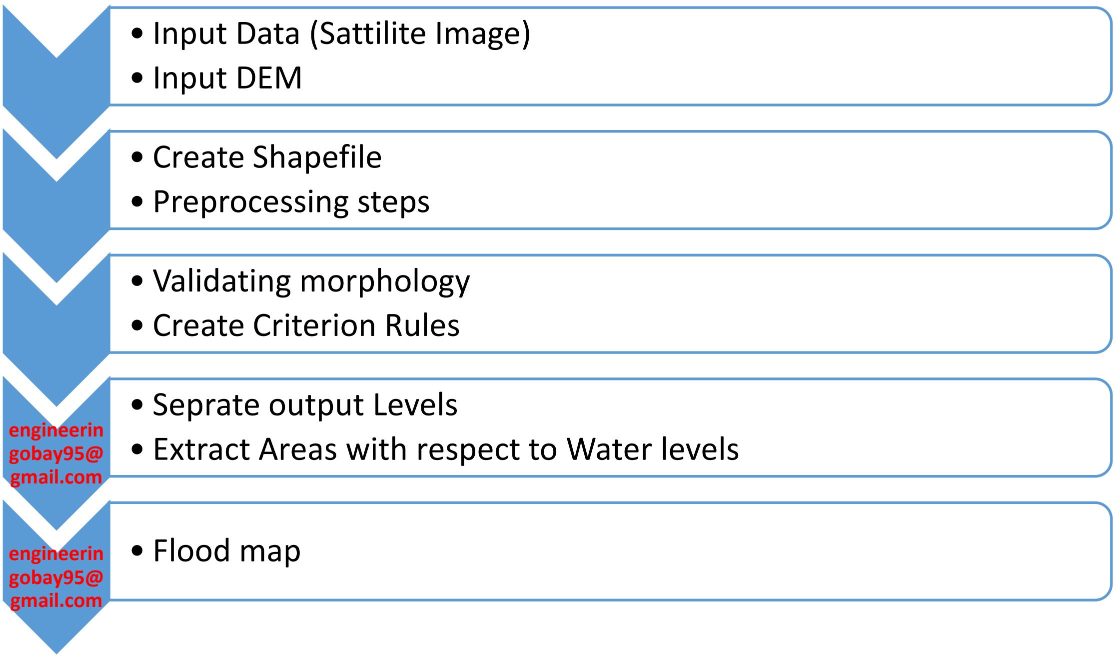

Figure 3: Process Diagram.

4. Results and Discussions

Completing previous operations was followed by outputs represented by determining the areas at risk of flooding at the height of the water levels mentioned in the study probability (3m, 4m, and 5m) above normal height. The results of calculating the contour are illustrated in Figure 4, representing a small piece of the studied area to be highlighted and readable.

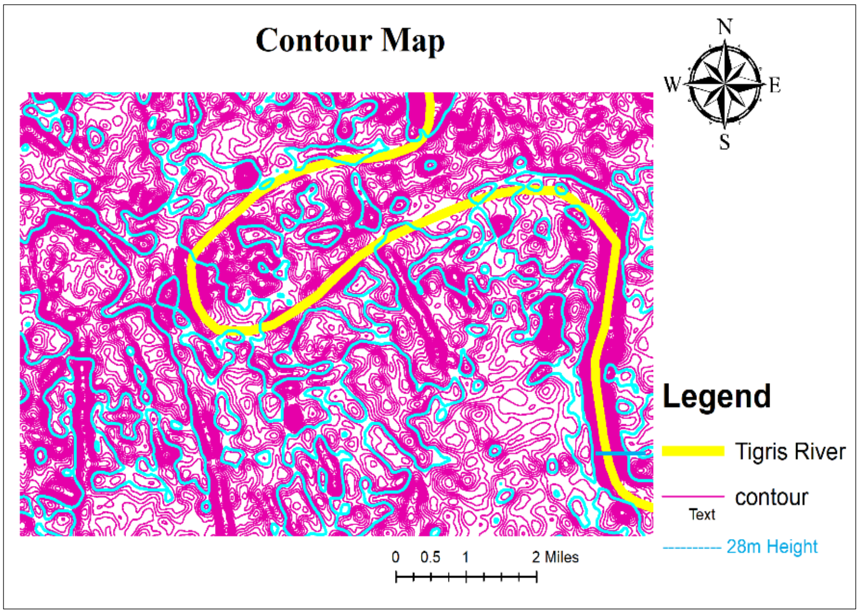

Figure 4: Contour Map Extraction

The following result illustrates the studied area's elevations; Figure 5 shows a decrease in the area's height south of Baghdad, which will be the red zone for flood hazards. The slope of the studied area is minimal, so the area that will be at risk is almost in the Al-Karkh district, especially in the south region.

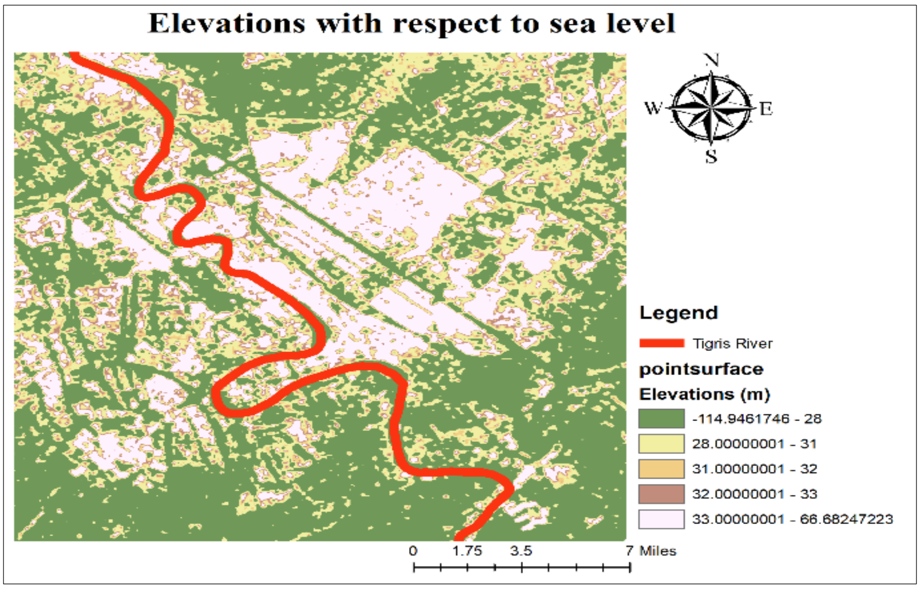

Figure 5: Level Variation of the Studied Area.

The final scenario is represented in Figures 6, 7, and 8. The map was illustrated by overlaying a road map on the base map. This step is necessary for defining the area and whether they are at risk. Figure 6 shows that the Tigris River flood has affected areas when it rises 3 m above the normal height.
Figure 7 represents the flooded area when the water level rises 4 m above the normal height.

The water could cover more areas represented by flooded roads. Nevertheless, the noticed sign is the considerable difference in the flooded area concerning the rise of the water level by 1 m between the two steps of the scenario.

The next step of this scenario is the 5 m rise in the water level illustrated in Figure 8. The figure shows the increase in the flooded area in the Al-Rusafa district with a clear view. In addition, the Al-Karkh district will be affected more by the flood hazard.

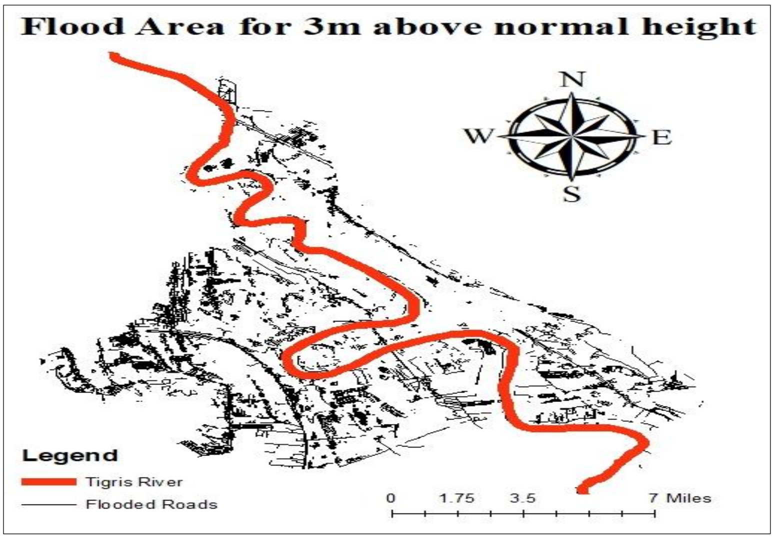

Figure 6: The Flooded area by raising the Tigris water level 3m above the Normal Height.

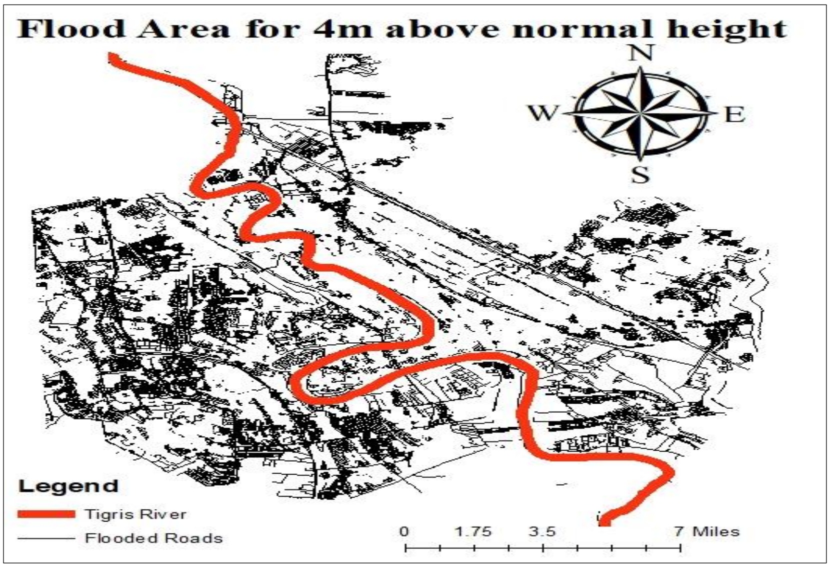

Figure 7: The Flooded area by rising the Tigris water level to 4m above the Normal Height.

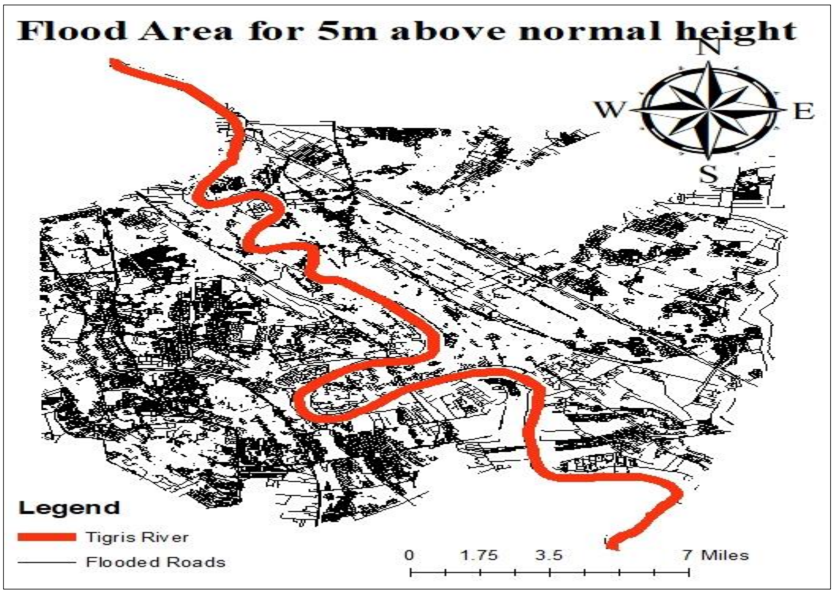

Figure 8: The Flooded area by rising the Tigris water level to 5m above the Normal Height.

5. Conclusion

Using the digital elevation model (DEM) is essential in determining the heights of the area affected by the flood and the elevation of water levels and using the appropriate tools in ArcGIS. The results showed a high flood risk when the Tigris River water rises above the normal height. The scenario showed that about 30% of the studied area would be affected by stage I (3 m), while about 50% will be at risk for stage II (4 m). Finally, about 70% of the studied area will be at risk of flood in stage III (5 m).

The research showed the roads that will be affected by floodwater concerning the rise in the Tigris River. The slight slope and little roughness affected the results of a very high rise in the flooded area through a 1 m increase in the water level height.

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