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Simulation of Extraordinary Flood Risks for the Diyala River Section Within the Abu Sayda and Al-salam Districts Using Hec-ras (Hydrological Study)

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Abstract

The current study included (simulating exceptional flood risks for the Diyala River section within the Abu Saida and Al Salam districts using Hec-Ras), as the study area is located between two latitudes (33°51'57"N - 33°58'29"N) north, and longitude (44°39'1.803"E - 44°49'49.808"E) E A section of the Diyala River was studied between Abu Sidon district in the north and Al-Salam district in the south. The length of the studied river section was about (39) km. During the study, maps were made that simulate exceptional floods for the period (2013-2022), as it became clear that the year 2019 witnessed exceptional floods. The maximum discharge reached (733) m3/s, and maps were created simulating flood levels according to four levels of water height, indicating the extent of its impact on land cover within the studied area. The study found that flood risk increases near the river, as the affected lands amounted to approximately (14.5 km2, within a coverage range of 500 Meter, the lands affected by the 2019 flood amounted to (3.5) km2, within a coverage range of 1000 Meter. Water-damaged lands within a coverage range of 1500 meters decreased, as it amounted to about (1.1) km2, out of the total number of affected lands. As a result of the 2019 flood, which amounted to (19) km2.

Keywords: *floods, Diyala River, environmental risks, Hec-Ras program.*

1. Introduction

The study area is located between two latitudes (33°51'57"N - 33°58'29"N) north, and longitude (44°39'1.803"E - 44°49'49.808"E) east. The study was conducted on a section of the Diyala River between Abu Sidon district in the north and Al-Salam district in the south. The length of the studied river section was about (39) km, see map.(1)

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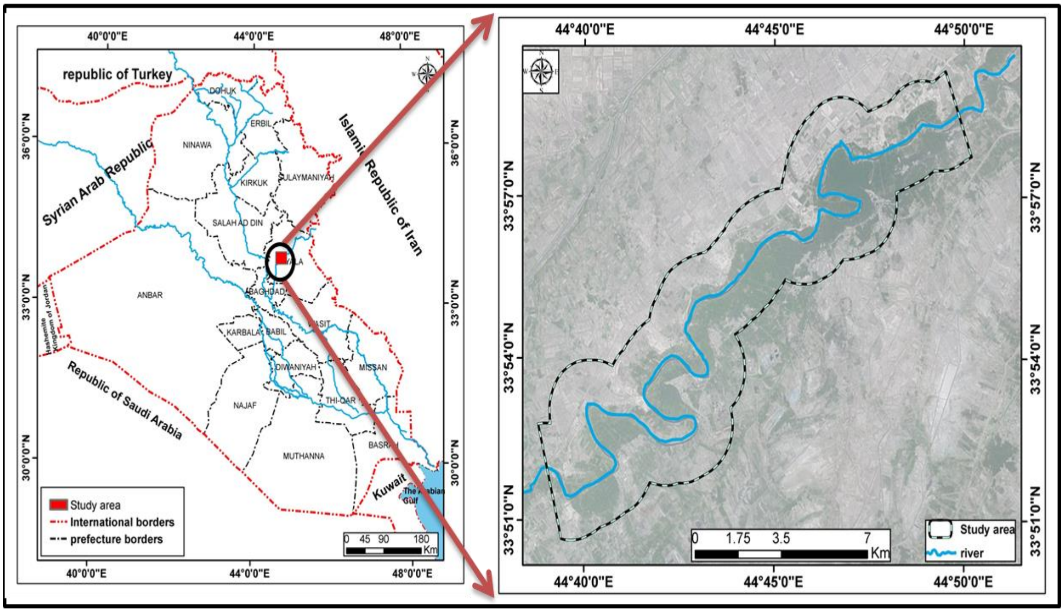


Map (1) Location of the Study Area in Iraq.
Source: Based on Ministry of Water Resources, the General Authority for Survey, the administrative map of Iraq, scale 1/1000000, year 2021, and the outputs of the Arc map 10.8 program.

The study area is exposed to exceptional floods without knowing the true extent of the flood damage, especially on agricultural lands and human settlements, and from here the following problem begins:

Is it possible to build maps that simulate the extent of flood damage using modern technologies?

This question represents the problem of the study and the basic question, while the hypothesis of the study is:

Building models that simulate the highest discharge for the period (2013-2022) using geographic techniques, including the Hec-Ras program, the Arc map program, and remote sensing technology.

The study aims to create models that simulate the rise of water according to an exceptional flood that occurred during the period (2013-2022) and to know the areal size of the areas affected by water.

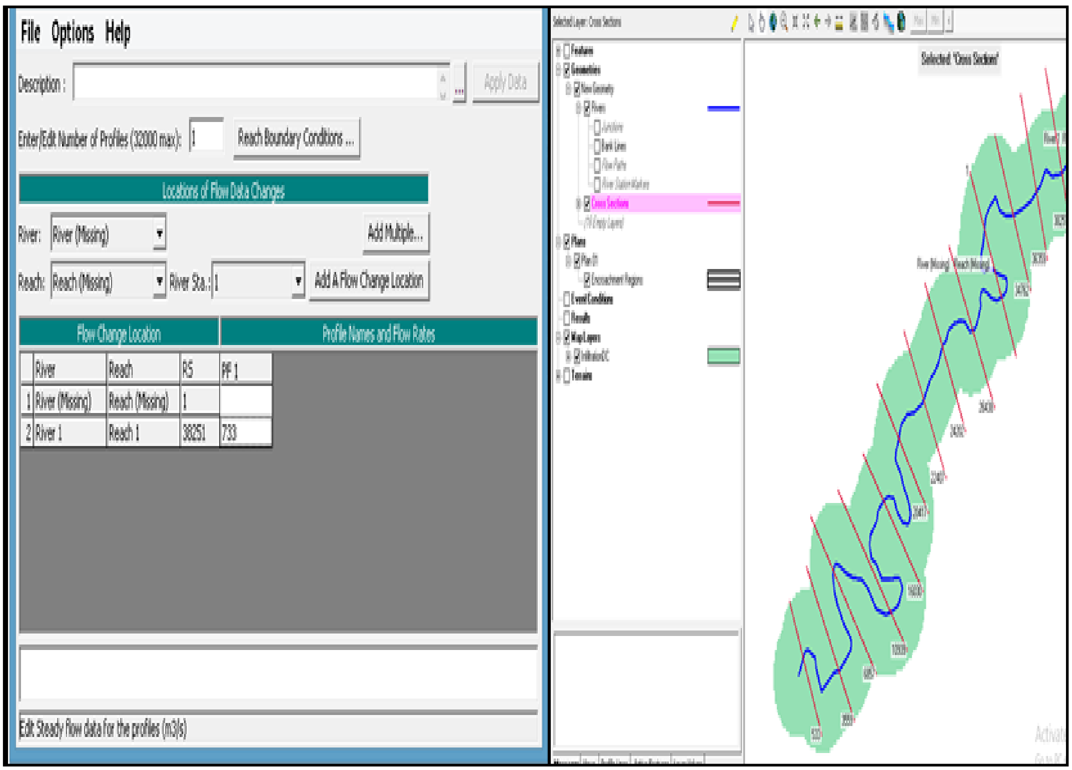
Worth to clarify the tools which are used in the research: Hec-Ras program, Arc map program, and remote sensing techniques.

Rivers are among the most important areas that humans have used to settle on the banks, as they provide them with easy transportation and a source of water. Despite the positives that living near rivers provides, they are not without inevitable risks and natural disasters, causing losses in human, economic, and material terms. The environmental impacts accompanying exceptional floods are the destruction of buildings and agricultural crops, and the destruction of roads, bridges, and engineering facilities. Floods are also accompanied by the spread of diseases and food shortages.

The study area is exposed to exceptional floods from time to time, which pose a threat to the nature of human uses. Due to the progress in geographic information systems software, it has become possible to avoid most of the environmental risks resulting from floods through the establishment of an early warning system that works to preserve the lives of residents and property. This research was done in Creating mapping models that simulate the rise in water levels when floods occur with the highest daily discharge levels for the period (2022-2013).

2. Hydrologic Modeling for the Flood Wave in 2019 Using Hec-Ras Program

The input for building a flood wave model within the Hec-Ras environment requires river discharge data to identify the maximum possible flood that may occur within an area, determine the course of the river, and conduct cross-sections of the river, see map no. (1) which shows conducting cross sections of the river course and entering the maximum flood wave for the period (2013-2022).



Map no. 1: Cross-Section the Course of the River and the Entry of the Maximum Flood Wave for the Period (2013-2022).
Source: Using the Program. Hec-Ras.

It is clear from Table (1) that the general rate during the study period (2013-2022) reached (95.5) m3/s, and it is clear that the years 2016 and 2019 recorded high rates, reaching (113, 329) m3/s, and on this basis, the year (2019) was considered a flood year, and on its basis, models were built that simulate the 2019 flood, as it becomes clear that the month of April recorded the highest water discharge, amounting to about (733) m3/s, as shown in Figure.(1)

Table (1) Monthly and Annual Discharge Rate (M3/S) of Hamrin Dam Station for the Period From(2022-2013)

Annual rate	Dec.	Nov.	Oct.	September	August	July	June	May	April	March	February	January	Years
62	48	32	51	65	78	74	56	54	79	97	51	56	2013
69	46	48	50	68	76	71	71	69	89	116	63	61	2014
48	72	31	37	46	48	50	45	47	55	54	50	39	2015
113	92	133	111	169	182	140	110	101	111	85	72	50	2016
84	100	111	70	96	107	103	70	60	93	74	67	59	2017
93	44	62	125	150	149	127	73	55	81	117	51	88	2018
329	114	225	300	267	233	230	239	508	733	448	473	177	2019
88	78	71	73	80	83	83	80	83	105	109	103	112	2020
39	31	30	30	23	35	31	30	31	40	69	39	82	2021
30	30	30	31	33	36	35	26	26	32	29	27	26	2022
95.5 General	65	77	88	100	103	94	80	103	142	120	100	75	Monthly rate

Source: Republic of Iraq, Ministry of Water Resources, National Center for Water Resources Management, Diyala River Drainage Records, Unpublished Data, 2022.

3. Modeling Flood Risks in Agricultural Areas

The agricultural profession is one of the most important activities practiced by the residents of the study area, and the rise in water levels plays an important role in the deterioration of agricultural areas and the submergence of large areas. The agricultural areas were extracted through wave classification in the program (ArcMap 10.8), and then a flood was modeled with a quantity Discharge of (733) m3/s, which is as happened in the 2019 flood, within the period (2013-2022), as noted in map.(2)

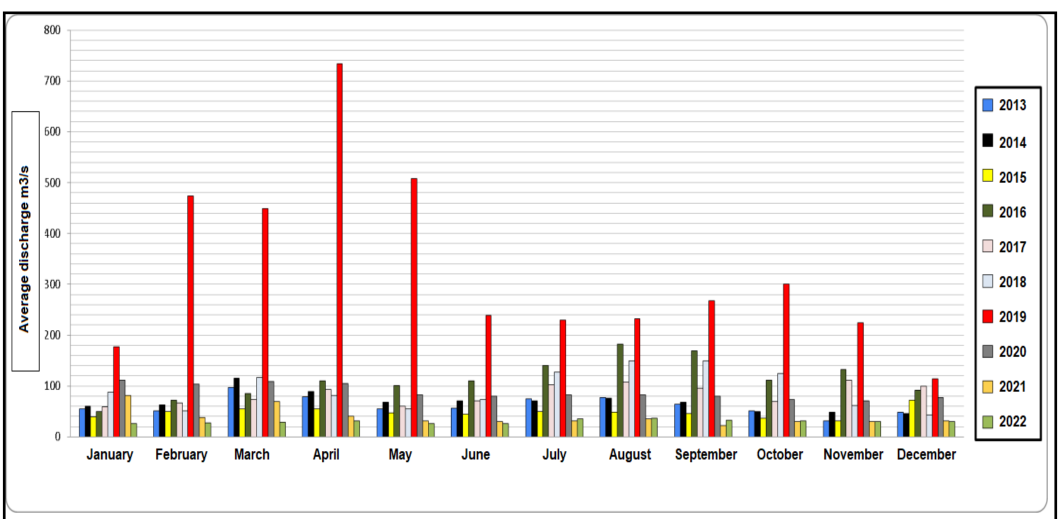
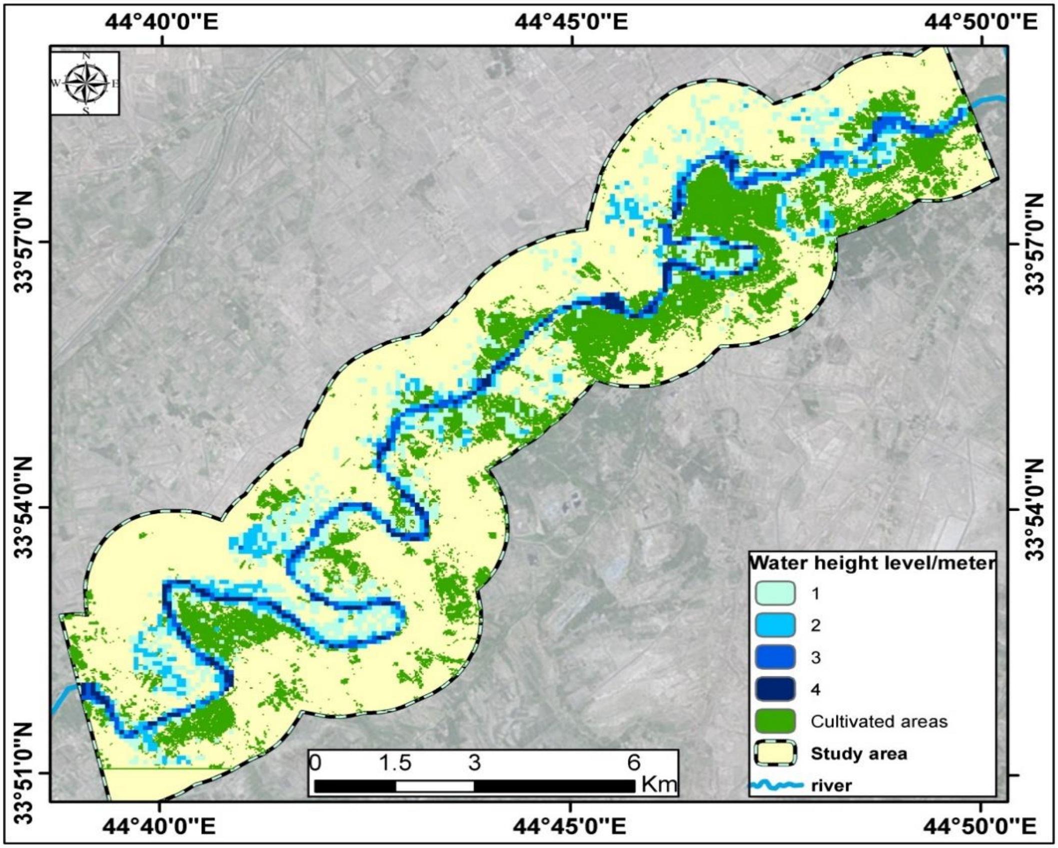


Figure (1): Annual Discharge Rate and General Rate M3/S for Hamrin Dam Station for the Period From.(2022-2013)

Source: Based on Table.(1)

It is clear from Table (2) that the area of agricultural land flooded with water varied because of the increase in the amount of drainage by (733) m3/s. The area of agricultural land flooded with water when the water level rose reached (1) m by (2.5) km2, while the areas Covered by water at a level of (4) m, it reached about (0.6) km2, and this is due to the concentration of agriculture near the stream, within its flood plain, as well as the low land compared to other areas.



Map (2): Risks of Rising Water on Agricultural Areas at A Discharge Amount of (733) M3/S.
Source: Worked by the Researcher Based on the Outputs of the arc Map 10.8 Program.

Table (2) Variation Around Agricultural Lands Flooded with Water at a Discharge Amount of (733) M3/s.

Area of flooded agricultural land / m2	Water height/m
2.5	1
1.0	2
1.6	3
0.6	4
5.7	Total

Source: The Work of the Researcher Based on the Outputs of the Hec Ras Program.

Third - Modeling the risks of floods on arable and plowed lands: The effect of the flood on the soil and plowed lands appears through the loss of its fertility and its exposure to erosion, especially the lands near the river. The total percentage of lands affected by the flood was about

(10.4) km2, as the highest area affected by the flood is at the level of the water height is approximately 1 meter, as shown in Table(3) .

Table (3) Variation Around Agricultural Land Flooded With Water at the Amount of Drainage (733) M3/s.

Water depth/m	Area of arable land, plowed and flooded/m2
1	5.2
2	2.5
3	1.7
4	1.0
Total	10.4

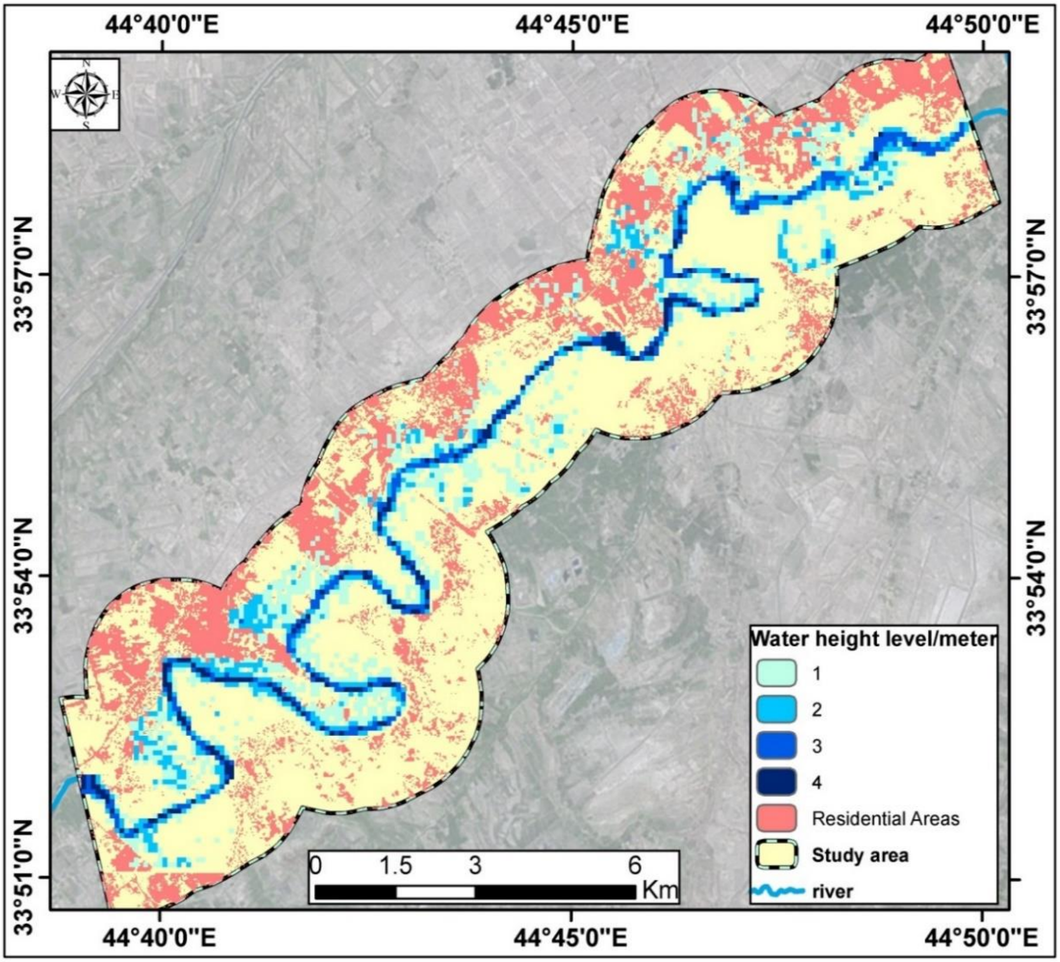
Source: The Work of the Researcher Based on the Outputs of the Hec Ras Program.

4. Modeling the Risks of Floods on Human Settlements

It was also not safe from the effects of the floods that occur in the region, as it submerges residential areas with water and forces residents to leave and abandon their homes, thus becoming homeless and homeless, in addition to the great losses that befall them because of their homes being flooded. The region may also become vulnerable to the spread of epidemics and diseases. In addition to pollution affecting drinking water. There is another danger that affects residential communities due to floods and torrents, which is that water submerges these areas quickly, but it takes a long time to return to what it was like before the flood.

The torrential risks of surface runoff water are related to the occurrence of very heavy rainstorms, which result in the flow of running water on the surface in large quantities, moving from one place to another according to the slope factor, and leaving behind unexpected damage and loss of life and property, considering the inability and absence of means of controlling floodwater. The phenomenon of floods or torrents in the arid and semi-arid regions, including the study area, is difficult to predict, as a result of its association with the suddenness and amount of precipitation, and since torrents are a phenomenon and humans do not have the ability to control the time of their occurrence or the amount of its intensity, it is necessary for it not to be a contributing cause in deepening its impact, including It causes a change in the characteristics of the natural environment (Israa Murad et al., 2023 : 364). Floods and torrents result in direct and indirect effects on the areas they sweep, which vary according to the strength and size of the flood and the country's social and economic nature and its ability to intervene and reduce these dangers and their direct effects, especially damage to infrastructure (bridges, roads, electricity, communication wires, industrial facilities, and the demolition of homes, displacing residents and making them homeless. The region may be exposed to epidemics such as typhoid or cholera because of shortages or pollution of potable water, with the possibility of contamination of agricultural crops. The study area is characterized by a random distribution of human settlements and extends along the Diyala River, and most of them are settlements. Note map (3).

From observing Table (4), the highest area of human settlements submerged in water reached an amount of (1.9) km2, when the water rose to a depth of (1) m. The reason for this is the settling of settlements near the banks of the stream to obtain water for various purposes, which exposes the population The flood occurred significantly in contrast to the settlements located far from the stream, as it reached (0.2) km2, at a depth of (3-4) m.



Map (3): Risks of Rising Water/from Human Settlements at the Amount of Discharge (733) M3/s.
Source: Worked by the Researcher Based on the Outputs of the Arc Map 10.8 Program.

Table (4): Area of Human Settlements Submerged in Water at a Discharge Amount of (733) M3/s.

Water height/m	Area of submerged human settlements / m2
1	1.9
2	0.8
3	0.2
4	0.2
Total	3.1

Source: Researcher Based on the Outputs of the Hecras Program.

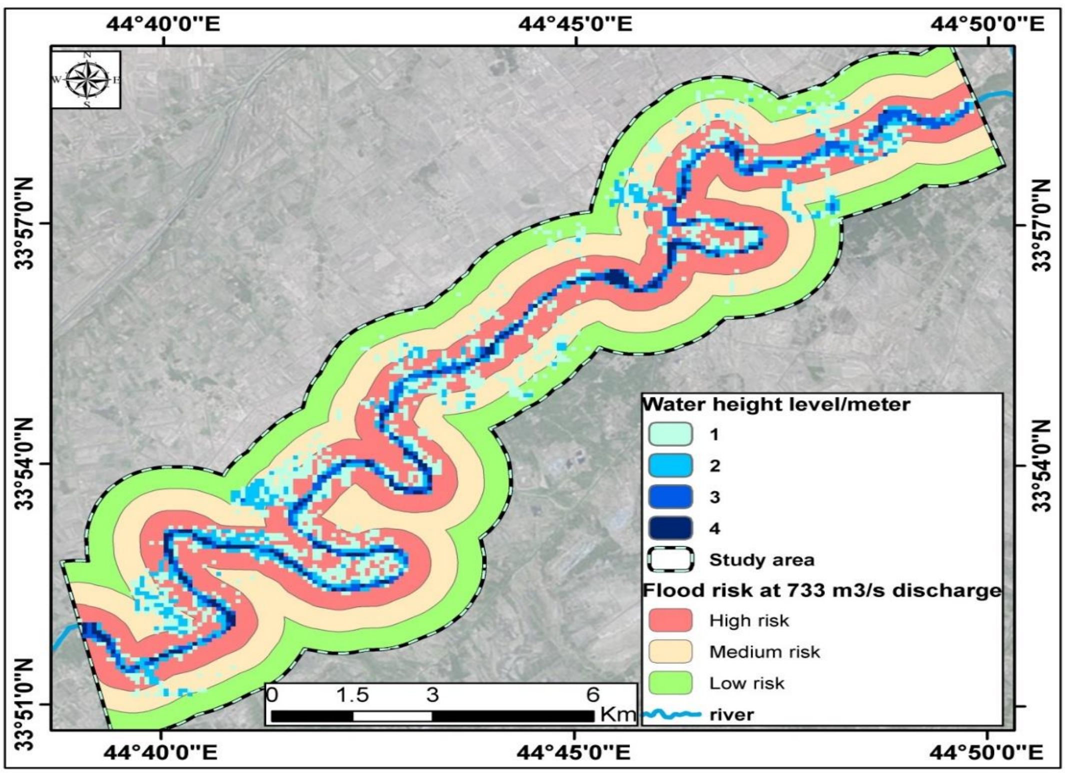
5. Modeling the Spatial Dimension of Flood Risk According to the 2019 Floo

After identifying the risks resulting from the 2019 flood wave, the effect of the spatial dimension of the 2019 flood wave was revealed, as three different areas were chosen in terms of the area they cover, and from observing Table (5) and Map (4), it appears that the closer we are to the river, the higher the flood risk. The opposite is true, and it is a natural result, as near the river the amount of water increases, as it ranges around 4 Meter, while it reaches around 1 meter within its floodplain, as the first scope included an area of (500) Meter, which are the areas close to the river, as the total affected lands amounted to The flood wave was approximately (14.5) km2, while the second scope included a coverage area of (1000) meters, and the affected lands within this scope amounted to an area of (3.5) km2, while the last scope included about (1.1) km2 according to a coverage area of (1500) Meter.

Table (5): The Spatial Dimension of Flood Risk According to Coverage Areas Within (500) Meters, (1000) Meters, and (1500) Meters.

Regions	Coverage range	Area of land affected by water/km2.
1	500	14.5
2	1000	3.5
3	1500	1.1
Total		19.1

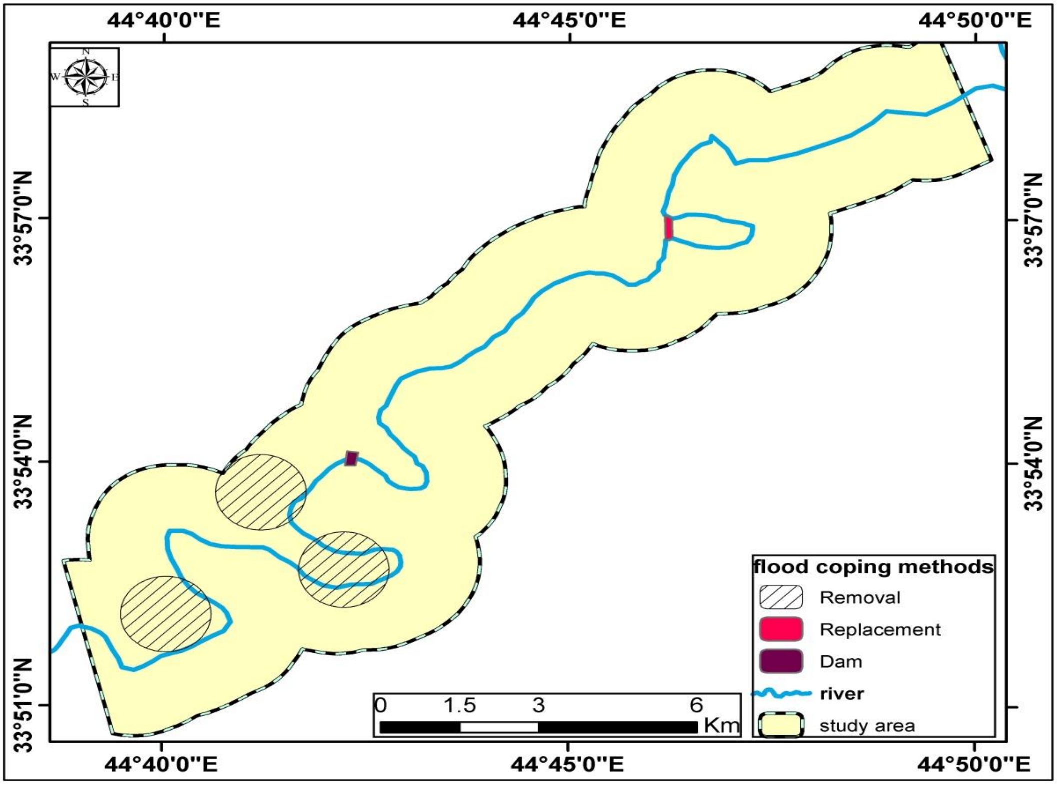
Source: Researcher Based on the Outputs of the Hecras Program.



Map (4) Shows the Spatial Dimension of the River Course.
Source: The Researcher Based on the Outputs of the Arc Map 10.8 Program.

6. Ways to Cope with Flood

After identifying the risk areas due to the occurrence of floods in the Diyala River section within the Abu Saida and Al-Salam districts, some measures must be put in place, the aim of which is to reduce the severity of the risk or reduce it to avoid and reduce its future effects. Map (5) is noted as follows- :



Map (5) Ways to Confront Floods.
Source: Worked by the Researcher Based on the Outputs of the Arc Map 10.8 Program.

To confront torrents and floods, a set of measures must be taken to reduce and prevent these dangers. These measures are arranged in accordance with the British Standard (OSAS of 2007) as follows (British Standard, 2007: 6).

- Removal
- Replacement
- Engineering control
- Personal protective equipment
- Signs and warning signs
- Removal: In which roads are removed from the depths of valleys and danger areas and moved to higher and safer lands to avoid their destruction (Mohammed Abdel Rahman, 2019: 322). Housing and facilities exposed to the recurrence of danger are removed.

Replacement: Alternative paths are created to direct floods away from populated areas and industrial facilities.

- Engineering control (water harvesting): This is done by constructing dams on valley streams to retain flood water and prevent it from flowing towards populated areas, facilities, and crops, and to benefit from it for irrigation or to increase groundwater reserves.

- Personal protection missions: They are carried out through warning methods, including remote sensing and early warning systems, which depend on measuring and observing hydro morphological variables over large areas of land, and the use of satellites and early warning aircraft (AWACS) after modifying its military system. This system contributes to giving A clear picture and information about the types of clouds and rain, their different characteristics, and the places where they move and collect (Ahmed Saleh Salem, 1989: 76), It may determine the beginning of water flow in small streams.
- Signs and warning signs: through which residents are warned and made aware of the dangers of floods, and the danger of living, building, farming, and establishing industrial facilities in valley streams, and explaining how to deal with floods before, during, and after their occurrence, in addition to providing accurate climate information, through establishing a network of stations to measure rain and floods. And recording their intensity and making use of and reviewing previous records and statistics available from some concerned authorities regarding the amounts of rain, for the purpose of taking the necessary precautions and developing solutions for the amount of falling rain due to which floods may occur (Latif Mazal Saleh, 2015: 220).

7. Conclusion

1. The highest annual discharge reached (329) m3/s for the period (2013-2022), as the highest monthly discharge reached (733) m3/s.
2. Water height levels were modeled according to the 2019 flood, as the highest water height level reached 4 meters within the lands near the river.
3. The total area of agricultural land submerged in water reached (5.7) m2, and the submerged areas varied according to the water level, as it reached (2.5) m2, at the 1-meter level, (1) m2, at the (2) m level, and (1.6) m2, At the level of (3) m, and (0.6 m2) at the level of 4 m.
4. The area of arable and plowed land reached (10.4) m2.
5. The area of human settlements submerged in water reached (3.1) m2.
6. The region was divided into three flood risk zones. The first zone, which is areas with high floods, reached the total area of land submerged in water according to the 2019 flood (agricultural land, arable soil, and human settlements) within a coverage area of 500 meters, about (14.5) km2, and about (3.1) km2 according to a coverage range of 1000 Meter, and the smallest area within the range of (1500) Meter, as it reached (1.1) km2

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