Research Article

Assessing Hydrological Characteristics in Iraq Dams

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Abstract | A dam is a hydraulic structure of impervious material constructed across a river or natural stream to create a reservoir to allow off-season storage of vital water supplies and for impounding water. Iraq is a country of limited water resources and a high demand for water due to its agricultural sector and its growing population. In this study, an analysis of hydrology characteristics of Iraqi dams has been presented which include DAM flow direction, mesh flow, agricultural area improvement, waterway division, and basin determination. These characteristics provide valuable insights into country's water resources management, including the optimization of water use for different purposes and the strategies' development to deal with water scarcity and drought. The analysis of hydrology characteristics in Iraqi dams has been conducted using remote sensing techniques and GIS. Due to its arid to semi-arid climate, limited water resources, and growing population, Iraq is facing significant challenges in managing water resources. Dams play a crucial role in managing the country's water resources through storing and releasing water during periods of high and low precipitation. Understanding the hydrology characteristics of Iraq dams is essential to sustainable water resource management. In this study, different types of dams have been selected (arch concrete, rock fill, rock with a lot of core and stone shell, and earth fill) with different storage capacities in m^3. Dam body length has also been determined at different execution times from 1958 to 1999. The hydrology characteristics of Iraq dams have been analyzed. These hydrology characteristics are DAM flow direction, Mesh flow clustered, agricultural area improvement, waterway division for ROI, and basin. The analysis of these characteristics provides insights into water resources management, including water allocation, irrigation planning, hydropower generation, and management of drought and water scarcity. To analyze the hydrology characteristics of Iraq dams and to conduct this analysis, remote sensing and GIS techniques have been used. The analysis of hydrology characteristics in Iraqi dams is crucial to ensure sustainable water resource management. This research provided a comprehensive overview of the current state of hydrology characteristics in Iraqi dams and to identify areas for further research and improvement. A GIS map has been used to analyze the flow direction and to identify areas of potential concern or risk, such as areas that are prone to flood or erosion. The results of this study can help inform strategies and water resource management policies to ensure the sustainable use of water resources in Iraq.

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Introduction

Hydrology is the scientific study of the movement, distribution, and quality of water on Earth. It treated all phases of Earth's water. There are many applications of hydrology found in such tasks, these are water supply, wastewater treatment and disposal, drainage, irrigation, flood control, hydropower generation, navigation, control of salinity, erosion, and sediment (Chow *et al*., 1988).

Hydrology deals with understanding the underlying physical and stochastic processes involved and estimating the quantity and quality of water in different phases (Maidment, 2016). Natural systems are increasingly being affected by human intervention such as the building of dams (Richter *et al*., 1996).

Systems of freshwater are threatened by human activities and stand to be further affected by anthropogenic climate change. Water systems are transformed through widespread land cover change, urbanization, industrialization, and engineering schemes like reservoirs, irrigation, and inter basin transfers that maximize human access to water (Meybeck, 2003; Walter *et al*., 2005; Karl *et al*., 2009; Vörösmarty *et al*., 2004).

Dams are one of the most important factors globally altering the hydro-morphological regime of rivers and negatively affecting their ecological functioning (Dynesius and Nilsson, 1994; FERC, 2018). The construction of small and medium dams everywhere aims at excess water collection and conservation of eroded soil, in addition to groundwater recharge (Younus, 2017).

The hydro-morphological regime of rivers is alternating dams and negatively affecting their ecological functioning (Dynesius and Nilsson, 1994; FERC, 2018). The construction of small and medium dams everywhere aims at excess water collection and conservation of eroded soil, in addition to groundwater recharge (Younus, 2017).

Sherard *et al*. (1963) has suggested that embankments containing both earth and rock should be termed as earth-rock 5 and the name rockfill reserved for dams built exclusively of rockfill. However, dams composed mainly of rockfill is customary referred to as rockfill dams (Sherard *et al*., 1963).

Earth fill dams may be designed of a wide range of cross sections and compositions, depending on the setting. They must be the optimum products of local materials and must be harmonized with their sites. One of its basic merits is adaptability to foundations that might be unsuitable for other types of dams. Although earth dams can accommodate to difficult site conditions, they still must be provided with foundations that support to keep deformations within acceptable limits. The simplest earth fill dam is the one commonly classified as homogeneous. This type is composed essentially of the same material throughout the embankment. Many embankments of this type have become a high-level saturated that their stability has become questionable (Robert *et al*., 1988).

A concrete arch dam is constructed as a system of monolithic blocks separated by contraction joints. The monoliths are constructed separately so that cooling and shrinkage may take place independently in each one. After construction period, contraction joints are grouted under high pressure to form a completely monolithic structure. Throughout the entire lifespan of dam, grouted joints can take little or no tension. Therefore, although the use of interface or joint elements to represent vertical joints has been mainly related to dynamic analysis (Boggs *et al*., 1988; FERC, 2018).

Materials and Methods

Different types of dams including arch concrete, rock fill, rock with a lot of core and stone shell, and earth fill, have been used in this study. These different types of dams have been built in different years between 1958 and 1999 and have variable reservoir capacity and body lengths. Table 1 and Figure 1 provided the specifications of the chosen dams.

For this investigation, DAM with accuracy Shuttle Radar Topography Mission1 (SRTM1) Arc-Second Global included improved water drainage modeling was downloaded from the American site https://earthexplorer.usgs.gov and used to define and study watershed, water flow, and its direction, created mesh flow clustered, determined the improvement of agricultural area, and ranked the basin's waterways to ROI as shown in Figure 2.

Table 1: *Large Dams constructed in Iraq are crucial to manage water resources and reduce flooding risk.*

Dam name	Lat.	Long.	Dam type	Storage capacity (m³)	Dam body length (m)	Execution date
Dokan	35.9542	44.9526	Concrete arch	6, 8 billion	360	1958
Darbandikhan	35.1132	45.7065	Rockfill	3, 8 billion	445	1961
Hemrin	34.1125	44.9702	Rock with mud core and stone shell	3, 5 billion	3500	1981
Haditha	34.2681	42.3758	Rockfill	8, 2 billion	8923	1985
Mosul	36.6303	42.8231	Rockfill	11, 11 billion	3650	1986
Dohuk	36.8758	43.0036	Earthfill	52 million	613	1988
Udhaim	34.5650	44.5156	Earth fill	1, 5 billion	3800	1999

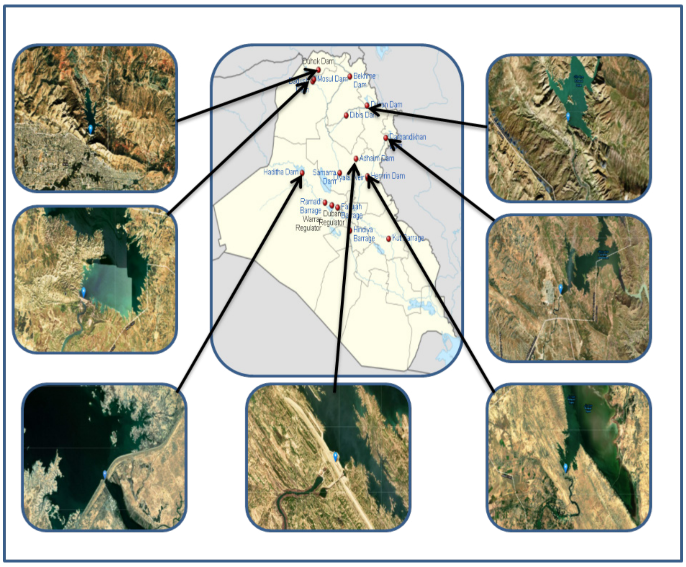

Figure 1: *The study area location, comprises seven DAMs of the ROI (Dokan, Darbandikhan, Hemrin, Haditha, Mosul, Dohuk, and Udhaim).*

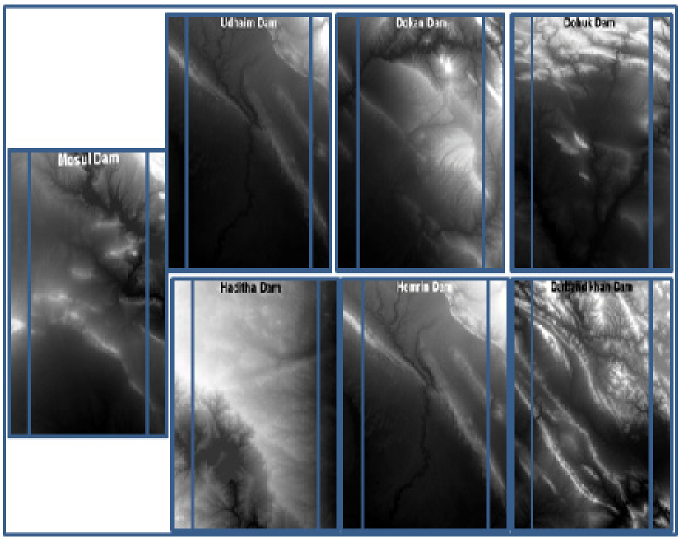

Figure 2: *DAM images SRTM1 accuracy was obtained for ROI to analyze the hydrology of study area.*

The coordinate system was converted from universal to metric system to determine the Region of Interest (ROI), as illustrated in the following Figure 3.

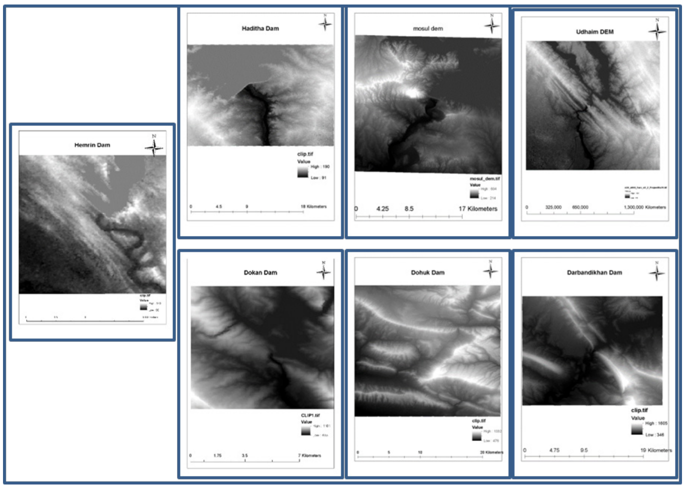

Figure 3: *Coordinate system converting from universal to metric form.*

The SRTM (Shuttle Radar Topography Mission) provided two levels of processing data. The first level involved void-filled Digital Elevation Model (DEM), which replaced missing elevation values with interpolated values. The second level involved the non-void version of data, which retains voids that has not been filled using interpolation or other sources of elevation. These issues have been addressed through the fill production process for Digital Elevation Model, which fills in the voids using appropriate techniques, as illustrated in Figure 4.

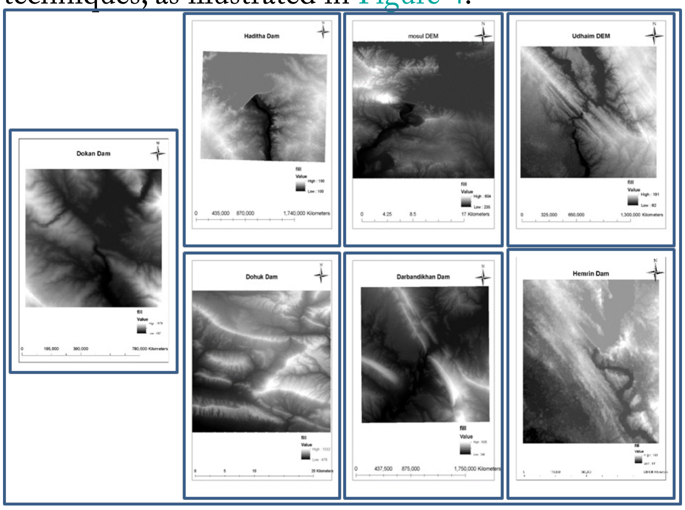

Figure 4: *Fill production of DAM.*

The determination of water flow from each cell to its surroundings in DEM of DAM has been achieved through the calculation of flow direction, as shown in Figure 5. A GIS map for DAM flow direction was created by Obtaining a DEM for the area around DAM using strem 1. Then process DEM to calculate water flow direction using hydrological modeling GIS software to create a layer shows the flow direction across the landscape. Then overlay flow direction layer on top of the map of the area around the dam achieved using GIS software to visualize the flow direction in relation to the dam and its surroundings.

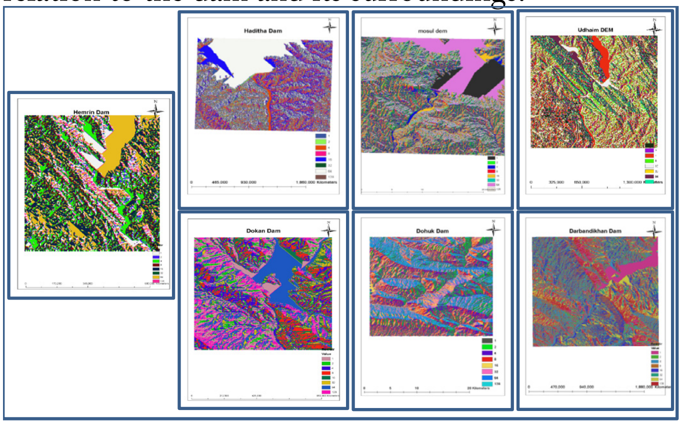

Figure 5: *DAM flow direction.*

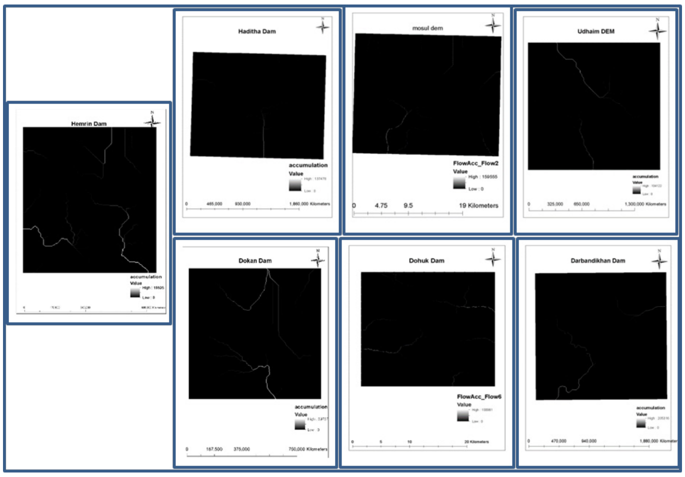

Figure 6: *Mesh flow clustered profile.*

Accumulation was achieved to create a mesh flow clustered in each cell, as shown in the following Figure 6. The flow direction of DAM map has been produced using GIS. The map included topography and elevation of the area around the dam. The accumulation process has been used to calculate the total flow that passed through each cell in DEM. This information has been used to create a mesh flow clustered in each cell, which is a representation of flow direction and magnitude within that cell. The accumulation process worked by starting at the cells with the lowest elevation and calculating the flow accumulation for each cell based on neighboring cells' flow direction. Then, the flow accumulation is added to each cell as the process moves uphill until it reaches the highest point in the drainage basin. Once the flow accumulation has been calculated for each cell, the information can be used to create a mesh flow clustered profile. This involved identifying the direction of flow in each cell and grouping cells with similar flow directions together to create a flow cluster. Then, the flow cluster can be visualized as a profile, showing the direction and magnitude of flow through the cell (Tarboton, 1997). Increase the improvement or the sensitivity of an agricultural area as shown in Figure 7.

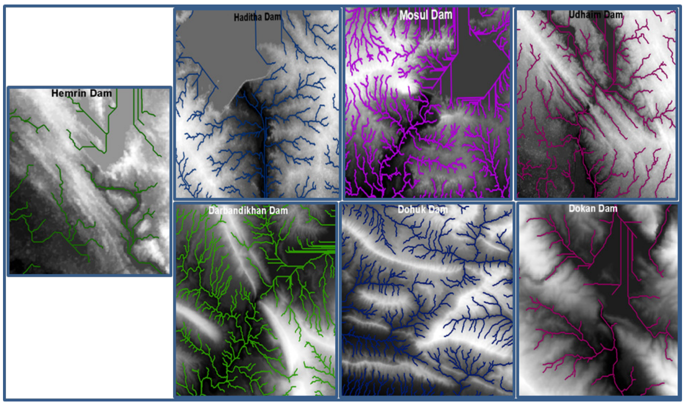

Figure 7: *The improvement in the agricultural area.*

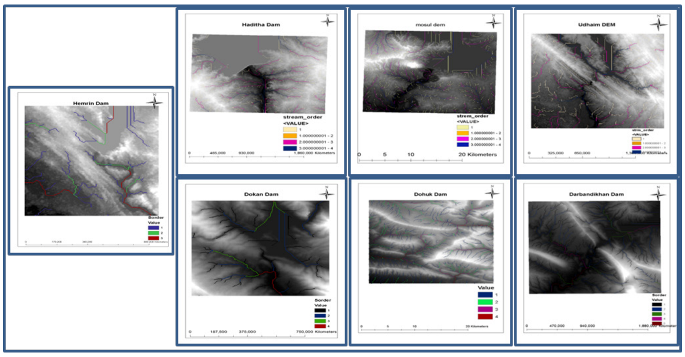

Figure 8: *Waterway division for the ROI.*

The determination of waterways ranks which means waterways division to degrees has done as shown in Figure 8.

The dam used basin Figure 9 involved identifying the watershed area that contributed water to the dam, which is important to understand the area hydrological characteristics, such as the water flow rate. The workflow to determine the dam basin using GIS is shown in Figure 9 by obtaining topographic data for the area surrounding the proposed dam site which include elevation data.

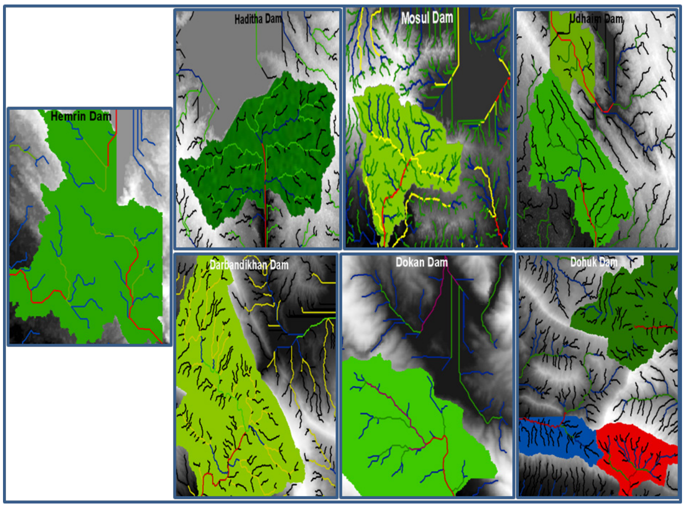

Figure 9: *Basin determination for the ROI.*

GIS is used to analyze the watershed hydrological characteristics which are flow rate and flow direction, to identify areas of potential concern or risk, such as areas that are prone to flood or erosion. And to measure the volume of water that will be stored in the dam.

Results and Discussion

Iraq is a country which relies heavily upon dams for water storage, irrigation, and power generation. The country has a few large dams, including Mosul Dam, Haditha Dam, and Al-Qadisiyah Dam, among others. These dams play a crucial role in the country's water management and agriculture.

One important aspect of dam design and operation is the analysis of hydrological properties. This involved studying the conduct of water in river basin, including rainfall patterns, runoff, and evaporation rates.

The results, which have been reached, agree with some studies used to analyze the hydrology characteristics in Iraq dams; these are:

Muhammed and Al-Ansari (2018) the Study analyzed the sedimentation rate in Mosul Dam Reservoir using GIS and remote sensing techniques Al-Ansari and Ezz-Aldeen (2019). Study and analyze the hydrological characteristics of Tigris River basin in Iraq, including the precipitation patterns, streamflow characteristics, and water quality. The study used statistical analysis and modeling to assess the water resources potential of the basin. The study used satellite imagery and field measurements to assess the sedimentation rate, which can affect the dam's storage capacity and the quality of water.

Conclusions and Recommendations

The use of GIS has proven to be a valuable tool for assessing the hydrological characteristics of dams in Iraq. In this study and through the analysis of various parameters such as DAM flow direction, Mesh flow clustered, improvement of the agricultural area, waterway division for ROI, and Basin, a comprehensive understanding of the current state of these dams has been provided. The results showed that many dams in Iraq are facing significant challenges regarding sedimentation, water scarcity, and inadequate maintenance, which could have serious implications for the sustainability of the country's water resources.

Acknowledgement

I am grateful to all team.

Novelty Statement

The results of this study can help inform strategies and water resource management policies to ensure the sustainable use of water resources in Iraq.

Author's Contribution

All authors make contributions to all aspects of the research.

Conflict of interest
The authors have declared no conflict of interest.

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