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Impact of water harvesting dam on the Wadi's morphology using digital elevation model Study case: Wadi Al-kanger, Sudan

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ABSTRACT

Remote sensing and GIS techniques are increasingly becoming an important tool in hydrology and water resources development; this is due to the fact that most of the data required for hydrological analysis can easily be obtained from remotely sensed images. These tools can be used in hydrology through determining the watershed geometry, drainage network, and other map-type information. The main objective of this work is to study the impacts of constructed dams on the Wagdi's morphology using A Digital Elevation Model (DEM). Digital elevation model derived from satellite image captured in tow different times, before dam construction and after dam construction, were used to study the Wadi morphology and how the dam a affect the direction of flow, It is clear that the Wadi diverted its channels towards the spillway and come again to its original channel after the dam. It can be stated here that if the spill way has been constructed with more higher elevation then it will help to keep the Wadi on its way and save more water that now escaping through the spill way.

Keywords: Water harvesting, GIS, remote sensing, Digital elevation model, watershed parametres

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INTRODUCTION

Water harvesting has many benefits, as it considered as an ideal solution of water problem in areas having inadequate water resources, contributes in rising the ground water level, mitigates the effect of drought and achieves drought proofing, reduces the runoff which causes flooding, improves the quality of water and reduce the soil erosion.

Remote sensing and GIS techniques are increasingly becoming an important tool in hydrology and water resources development; this is due to the fact that most of the data required for hydrological analysis can easily be obtained from remotely sensed images. Moreover remote sensing can provide a measurement of many hydrological variables used in hydrological and environmental models applications comparable to traditional forms.

The possibility of rapidly combining data of different types in a GIS has led to significant increase in its use in hydrological applications. These tools can be used in hydrology through determining the watershed geometry, drainage network, and other map-type information. Much research has focused on stream and watershed delineation and, in general, on watershed analysis based on topographic data. Digital Elevation Model (DEM) is generally produced by photogrammetric techniques from stereo-photo pairs, stereo satellite images or interpolation of elevation data. The derivation of such information through the using remote sensing and GIS would be very useful in site selection and designing of water harvesting project with minimum cost, efforts and time compared to the traditional methods in addition to giving an accurate results.

The main objective of this research is to implement DEM with different temporal resolution to determine the impacts of an existing water harvesting dam on the morphological shape of the Wadi.

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Methodology

This study was conducted in Wadi Al-kanger, which located 65 km North of Khartoum, Sudan (Figure 1). The area is characterized by annual rainfall of 200 mm. Where it rains, the rainy season is limited to 2-3 months with the rest of the year virtually dry. Rainfall usually occurs in isolated showers, which vary considerably in duration, location, and from year to year. The coefficient of variation of the annual rainfall in this Northern half of the country could be as high as 100 percent. The mean temperature ranges from 30^{o}C to 40^{o} C in summer and from 10 ^{o}C to 25^{o}C in winter.

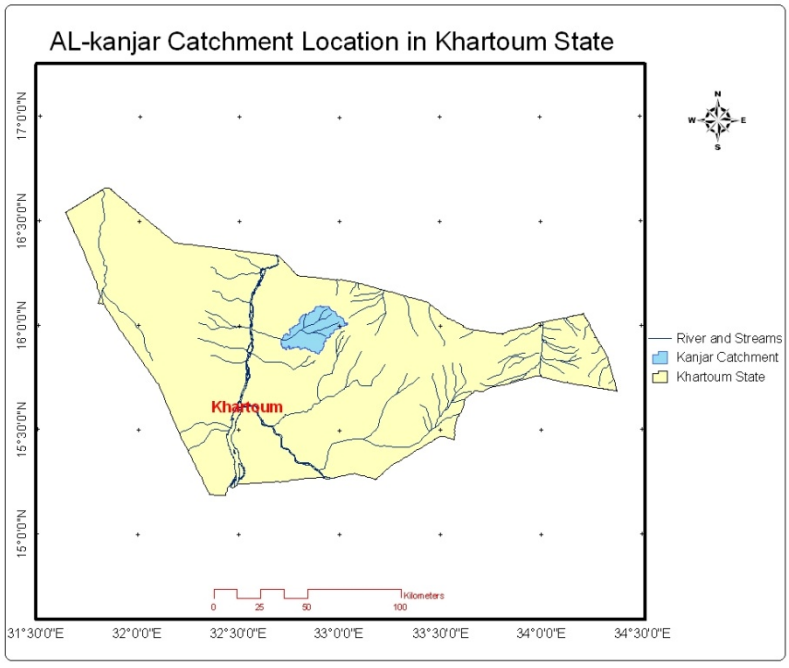

Figure (1): Location of the study area

Digital GIS data was gathered from relevant authorities and developed from different sources. While non-spatial data was gathered from libraries, local organizations, individuals and the internet. Contacts were also made with relevant ministries.

All spatial manipulations, analyses, and representations, were done within GIS that was used to produce pertinent spatial coverage. These included base map, topographic map and hydrological

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maps. For the first step, all needed spatial data were assembled either from paper source or digital format. Flow direction, flow accumulation, streams network and watershed boundaries were processed from the DEM using existing outlet point.

ARCHYDRO tool extension in the ARCGIS 9.3 environment was used to process the DEM and produce the fore saying maps.

Based on the grid cells system, the digital elevation model (DEM) technique can be used to provide basic input data. Flow direction, slope and aspect of grids can be computed from DEM based on the terrain analysis and relative hydrological parameter determination methods (Baillard et al.,1998, 2000).

Results and Discussion

The DEM of different temporal resolution, before and after the dam construction was processed to remove depressions that cause non-contributing area to be formed in the basin. Figure (2) represent the DEM for the study area.

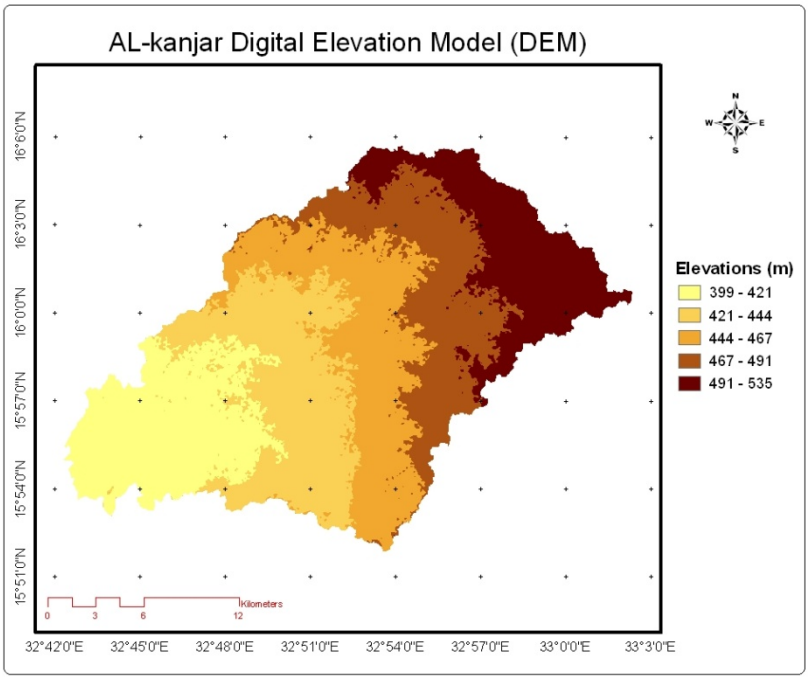

Figure (2): Digital Elevation Model for the study area

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Flow directions were needed in hydrology to determine the paths of water movement. A grid representing flow direction is produced from the DEM. From the flow direction grid, the flow accumulation grid is formed. Once the flow accumulation grid is formed, the stream grid is usually defined as the grid cells where the flow accumulation grid exceeds a certain threshold of contributing area. These raster streams are then vectorized to form a set of stream lines as shown in figure (3). This figure created from a DEM developed before the construction of the dam.

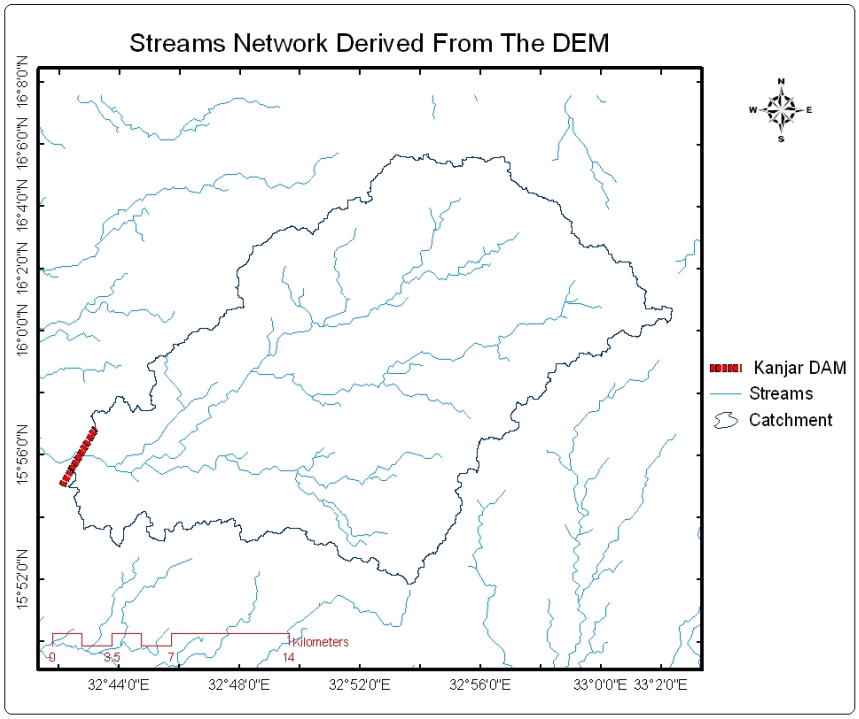

Figure (3): Streams network in the watershed before dam construction

A watershed is the upslope area contributing flow to a given location. Such an area is also referred to as a basin, catchment or contributing area. Watershed was delineated from a DEM by computing the flow direction and using it in the watershed function. The watershed function uses a raster of flow direction to determine contributing area.

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The pour point was used with the flow accumulation threshold to delineate the watershed. When the threshold is used to define a watershed, the pour points for the watershed will be the junctions of a stream network derived from flow accumulation. Therefore, a flow accumulation raster must be specified as well as the minimum number of cells that constitute a stream (the threshold value), When a feature dataset is used to define a watershed, the features identify the pour point.

Digital elevation model derived from satellite image captured in tow different times (before dam construction and after dam construction) were used to study the Wadi morphology and how the dam affect the direction of flow. Figure (4) represent the shape of streams derived from DEM captured before the dam installation.

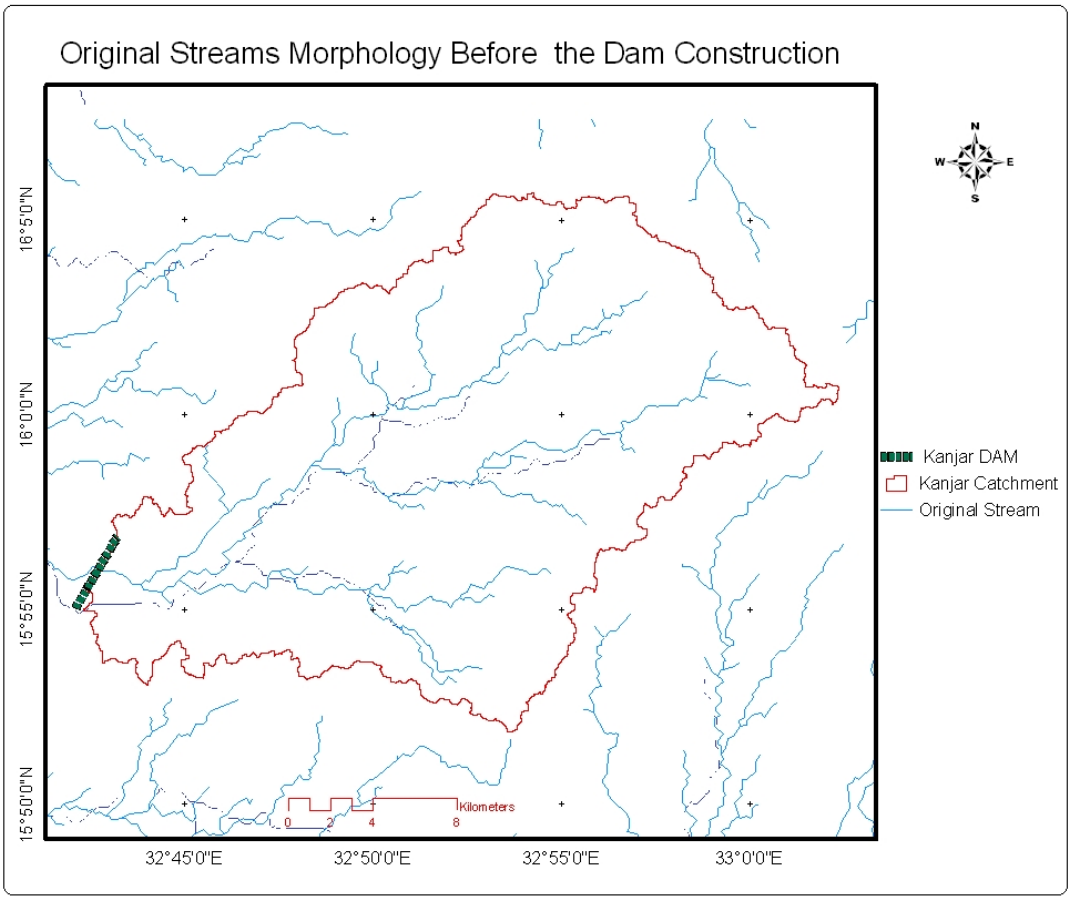

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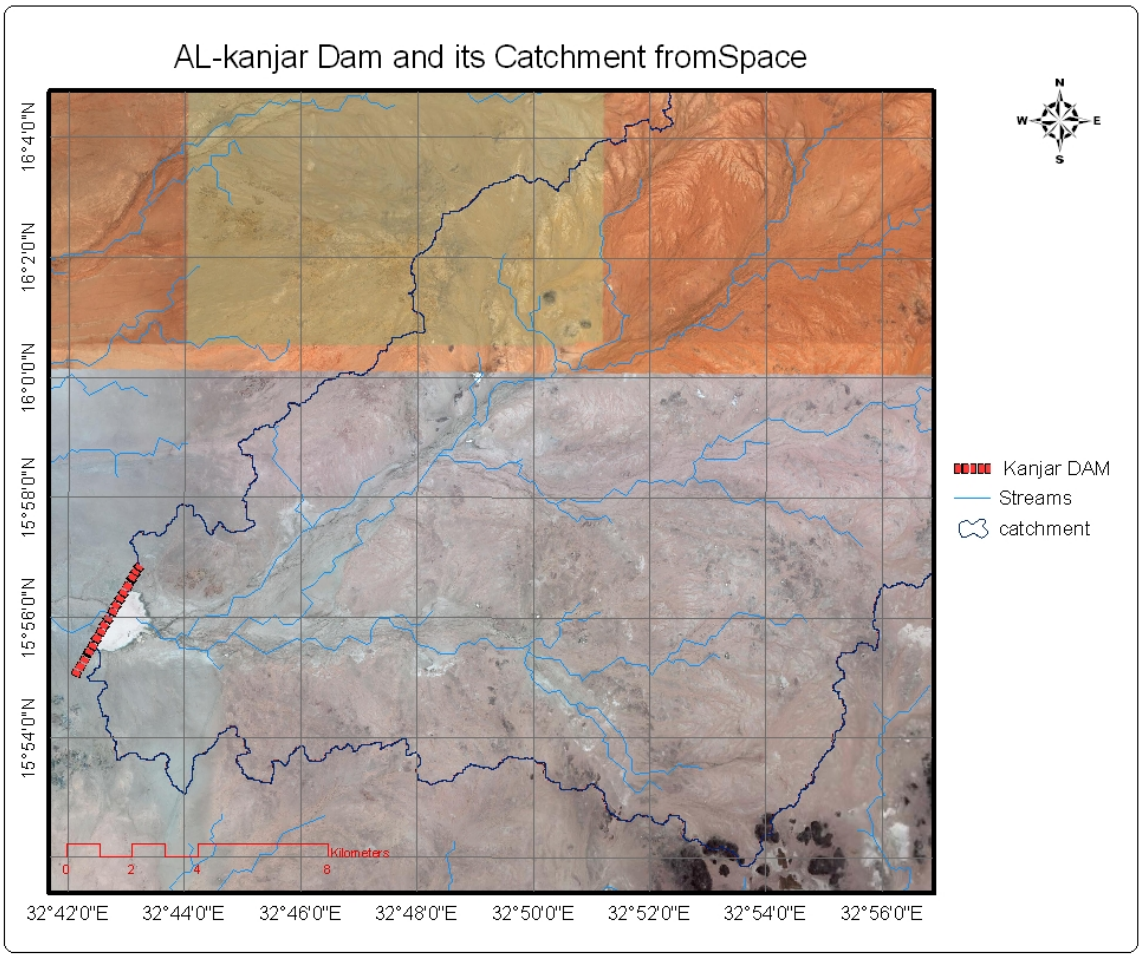
Figure (4): Original stream morphology before the dam construction

Figure (5) represent a LANDSAT satellite image for the area showing the original streams and some stored water.



It can be observed that the morphology of the Wadi is identical in both figures (4 & 5), this also approved that DEM can be used successfully to derive the streams network.

A digital elevation model derived from image captured after the dam construction was used to delineate the flow direction, flow accumulation, and the stream network for the area of the area. The newly produced steams where plotted with the original streams and shown in (Figure 6).

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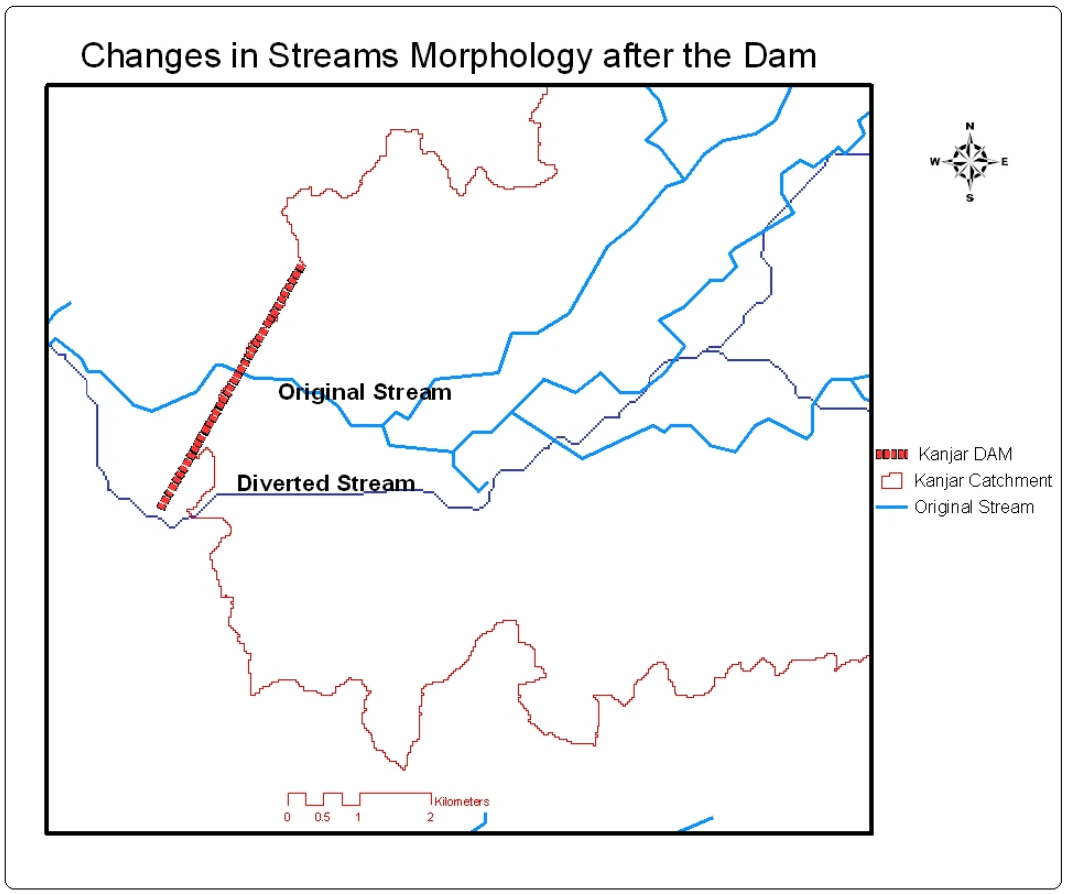

Figure 6: Changes in the streams morphology due to dam construction

Through the observations in the outlet point location it can be stated here clearly that the direction of the stream has been changed to flow southward in the direction of the spillway that constructed at the south part of the dam to avoid the overflow during the rainy season. It can be concluded here that Wadi morphology has been changed due to this dam. It is clear that the Wadi diverted its channels towards the spillway and come again to its original channel after passing the dam body.

If the spill way has been constructed with higher elevation than the exiting one then it will help to keep the Wadi on its way and save more water that now escaping through the spill way. Moreover the control valves in the four outlet pipes was installed in the downstream side which

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leads to block these pipes with sediments and cannot drain any water from upstream side, the water either diverted its way to the spill or wait until evaporated and this what happing now. It is recommend that to put valves in the upstream side to avoid the sediment blockage and use these pipes to drain the water when needed to avoid the overflow and to supply water to downstream side upon request.

Conclusion:

Remote sensing and GIS techniques are increasingly becoming an important tool in hydrology and water resources development; the possibility of rapidly combining data of different types in a GIS has led to significant increase in its use in hydrological applications. These tools can be used in hydrology through determining the watershed geometry and other map type information. Digital elevation model derived from satellite image captured in tow different times (before dam construction and after dam construction) were used to study the Wadi morphology and how the dam affect the direction of flow, It is clear that the Wadi diverted its channels towards the spillway and come again to its original channel after the dam. It can be stated here that if the spill way has been constructed with higher level then it will help to keep the Wadi on its way and save more water that now escaping through the spill way.

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