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HYDROLOGICAL WATER SIMULATION MODELLING USING HEC-RAS AND GEO-HECRAS FOR WATERSHEDMANAGEMENT ALONG RIVER KOGI AT CHALLAWA KUMBOSTO LGA KANO STATE

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ABSTRACT
In many developing countries water has become one of the topmost priorities for resource management, and this may affect the environment and the outcome of the production and which it impact differs due to its geological and hydrological settings. In an attempt to adopted hydrologic engineering center river analysis system (HEC-RAS) and

INTRODUCTION
Adequate knowledge of rainfall-runoff processes is vital to estimate the amount of runoff produced within a given catchment. Knowing the amount of runoff within a given catchment is important for sustainable water resources project planning and management. (Vaze, 2012).Water is the major source of life to all humanities; it is fundamental to biodiversity of all living organism and life blood of our planet. The planet ecosystem is linked and maintained by water which drives plant growth otherwise water is life. water is important for maintaining a vibrant economy (Bichi,*et al* 2003).A watershed is an area that supplies water by surface or subsurface flow to a given drainage system or body of water, be it a stream, river, wetland, lake, or ocean. It is considered as the basic unit of water supply and the basic building block for integrated planning of land and water use ,is consider to be one of the most fundamental

Geographical hydrologic engineering center river analysis system (Geo-HECRAS) simulation model along river Kogi at Magasawa village Kumbosto local government area Kano State North-Eastern Nigeria, to examine the rainfall and surface runoff and the peak discharge of the river. In the study area Hec-Ras model is used to describe the hydraulic behavior of this system, the river reach selected along the river threshold, from an image LANDSTAT the area, has been divided into 20 cross sections perpendicular to the flow directions numbered 1 to 20. ArcGis was used to extract the bathymetry for each cross section, this allow to creating the river geometry with Hec-Ras. The stream flow has successively fixed as upstream boundaries. For each stream flow, Hec-ras calculate the flow characteristics. The high and low characteristics areas have been located. The most of these stream parameter decreases for upstream to downstream. In general, the result shows that in the study area. Based on the findings of the study it is recommended that investor friendly environment should be created for those willing to invest to avoid environmental mismanagement.

Keywords: *Water flow parameter, Landstat, ARCGIS, HEC-RAS and GEO-HECRAS software*

factors controlling human activities including irrigation in every part of the earth by adopting various methods of water management practices throughout the history of man.

World population is increasing very rapidly, with increasing pressure on food supply and the environment; this leads to competition of utilization of water and environmental degradation which is becoming an issue the united state Army corps of engineering (USACE, 2015). Availability of water is becoming a limiting factor, in dry lands in dry lands part of the world where water is very scarce due to the nature of climate on how it affects the areas that is why water management is very necessary for effect food production and supply for day to day activities. The activities to estimate runoff volumes, flood peaks and watershed can be easily simplified by adopting a modeling concept and by understanding rainfall partitioning and the principal triggering runoff. (Zhang, *et.al* 2004),

The type of the modeling approach normally depends on the purpose, data availability and ease of use (Beven, 2012). Rainfall-runoff models are often used as a tool for a wide range of tasks, such as the modeling of flood events, the monitoring of water levels during different water conditions or the prediction of floods (Jia&Zhao, *et.al* 2009). Generally, hydrological models can be classified as stochastic and deterministic. The stochastic models will produce outputs that have partial randomness but the deterministic models on the other hand do not give randomness. The Hydrologic Modeling System HEC-RAS, which is a hydrologic modeling software developed by the US Army Corps of Engineers Hydrologic Engineering Center -River Analysis System(HEC-RAS) is an integrated modeling tool for all hydrologic processes of dendritic watershed systems. It consists of different component processes for rainfall loss, direct runoff, and routing. HEC-RAS has become very popular and been adopted in many hydrological studies because of its ability in the simulation of runoff both in short and longtime events, its simplicity to operate, and use of common methods (Halwatura,2013). Hydrographs developed by HEC-RAS either directly or in conjunction with other software's are used for studies of urban drainage, water availability, future urbanization impact, flow forecasting, flood damage reduction, floodplain regulation, and systems operation

Study Area

The study area is located in the North-western part which river Kogi flows along Magasawa village, it is a tributary of Challawa river, with geographical coordinates N11'87".030" and N8'48".40" East, with an Elevation of 441.34m at Challawa in Kumbosto LGA of Kano state. The terrain of the study area is characterized and covered by loose sand and lateric capping that is the weathered layer and the basement complex: the weathered layer are mainly lateric/sandy soil no occurrence of clay is fresh and has signs of wreathed property (Olofin and Tanko, 2003

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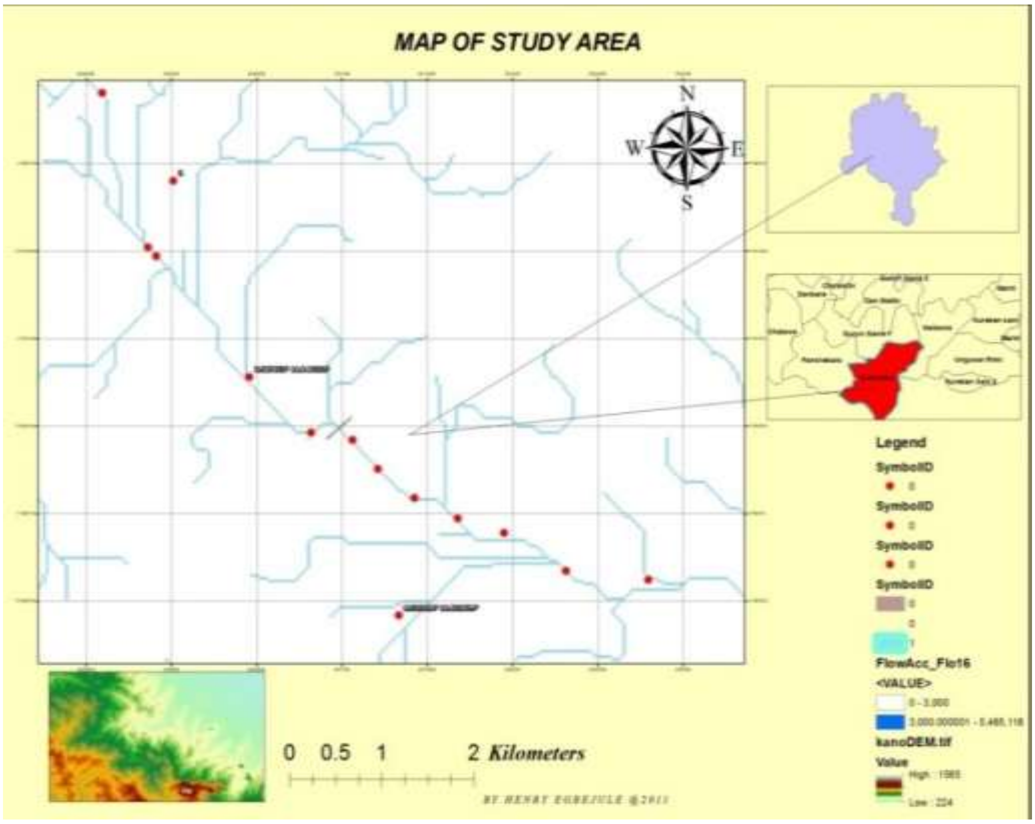

Fig 1: map of the study area
Source: Arc Gis 10.4, GeographyDepartment Lab Bayero University

MATERIAL AND METHOD

Geological reconnaissance survey will be carried out during the course of data acquisition to locate the water flow patterns and trends to familiarize with the study areas and also to see physical the nature of the environment including the terrain as well as the vegetation and the activities of the people will not be left out.

Garmin 76 Global positioning system (GPS) is use to carry the resonance of the area to find out the total land space cover. portion was selected in the study area which the river flow to determine the flow direction which is the upstream, after determining the suitable location carefully to ensure it flow freely to the downstream.

A portion was mark using a peg at one end and across to the other end attaching the rope at each end and the width is measured W1 station A' and A'' (cross-section) upstream is measured in meters and using the GPS to get the elevation at (A' and A'') then an interval 5meter was given

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at each station space of 20meter length and elevation was measured between station B' and B" (cross-section) downstream and the width station (A'- A") and that of (B'-B") of both is measured W2. The rope is divided into a portion of 1m interval of the ropes the length Llob, Lch, Lrob and Qlob, Qch, Qrobat both ends for the upstream and downstream at each mark at 1m interval measure the depth D1, D2and D3 and d1, d2 and d3 respectively. Using a flow method, the plastic bottle was released at the upstream the bottle is half filled with water using a stopwatch to measure the floating of the bottle to the downstream this is repeated at least 10 times and the average of the time is recorded to obtain the discharge Q in m/sec (Sq). (Brunner, 2016)

METHOD OF DATA ANALYSIS

A good understanding of the topographical, hydrological and climatic condition of the study area and proper set of data defining them are very important for analyzing and replicating the actual hydrologic and hydraulic situation and the data collected from the survey. Further, the quality of data used for modeling directly affects the output, so the collected data should be screened and processed before using them

Data for Hydrologic Modeling: HEC-RAS

Data required for hydrologic modeling (HEC-RAS) are:

Digital Elevation Model (DEM)

To determine the magnitude of the watershed GIS-software will be used. Arc-GIS 10.4 and HEC-GeoRas would be used for Digital Elevation Model (DEM) of 30 meters Resolution and slope analysis Ras mapper will be used to re-classify the area in to different catchment, tributaries and Buffering analysis will be carried out to determine areas that fall with the watershed (Alcamo *et al*, 2000)

Climate data (precipitation)

identifying and examine the precipitation guidelines documents from the federal ministry of environment rainfall data will be collected from 2009 to 2019 will be coded in to the HEC-RAS Software and Microsoft excel, descriptive statistical analysis such as tables, charts in SPSS will be used

Flow data

Water surface profile between any two cross sections is calculated by solving the energy equation (v) in an iterative way. This process is called as standard step method. The calculation proceeds upstream if the flow is subcritical and downstream if the flow is supercritical. (Brunner, 2016). For the computation of water surface, each cross-section of river is divided into left overbank, main channel and right over bank and the energy is calculated for each section

RESULT AND DISCUSSION

Water surface area

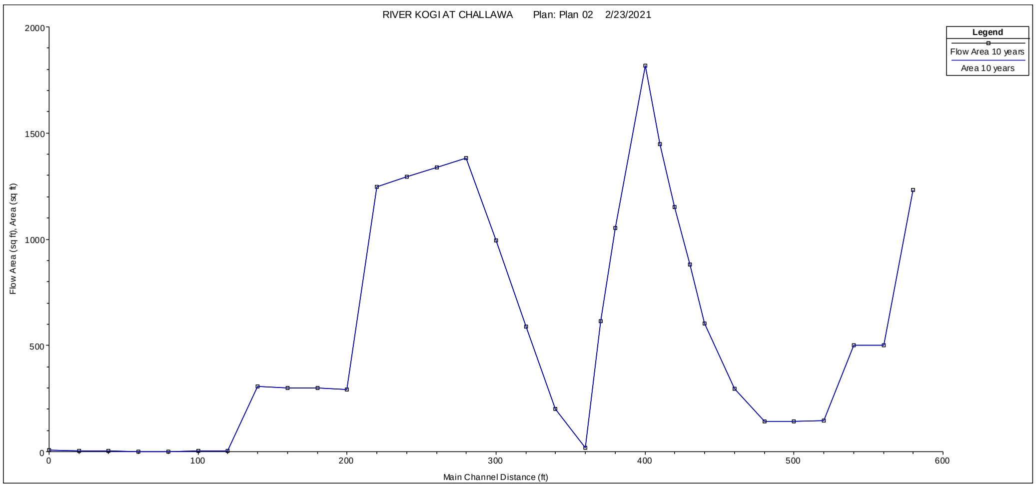
Flow is important to determine the shape and size a river is going to take, measuring the flow of the river is to understand at what certain point at a particular time. The study area has been divided into 20 Station (cross-sections).The stations 1, 5, 12 and, 20. It was observed at section 1 and 5 are narrow and cross-section 12 and 20 are with a width of 10 to 30m wide, their features shows a narrow rectangular smooth flow, not to wide and not to deep and the length (L), width (W) and depth (D) are measured and calculated with the time taking for the flow from Upstream to downstream (table1)

Table: 1 the discharges on the watershed

Station	Length (M)	Depth (M)	Width (M)	Area(m2)	AvgTime (sec)	Discharge(Qc m3/sec)
1	20	0.59	14	8.37	29.26	2.03
5	20	0.78	18	14.11	24.68	2.99
12	20	0.85	20	17.08	29.01	1.34
20	20	0.87	24	20.88	30.88	2.36

Source: Study area field data 2021

Fig 2 Surface area of the watershed

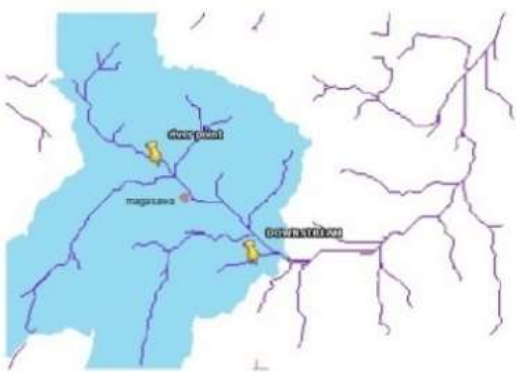


Source: Data analysis for Hec-Ras software 2021

Cross-sections

Cross sections plots at river station 20, 12, 5 and 1; in (Fig 2) interpolated cross sections plots between river station 19, 18, 17 and15, 11 and 9, 8 and 1. These cross sections have not the same width because of significant changes in the topography of the bed at Kogi River. It's been observed in these examples that the cross sections 1 to 8 are narrow with 10 to 17 wide widths with smooth flow and cross sections 18, 19 and 20 are larger. This is due to the significant change in the topography of Hadejia river bed.

Fig 3 Cross-section areas



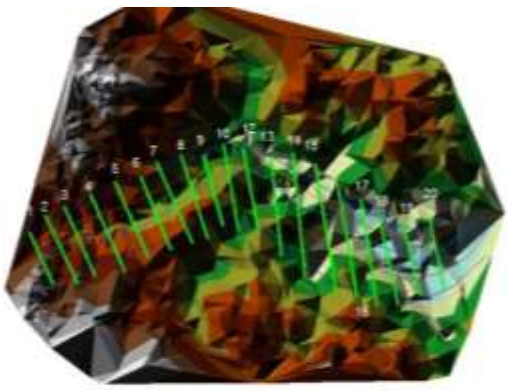
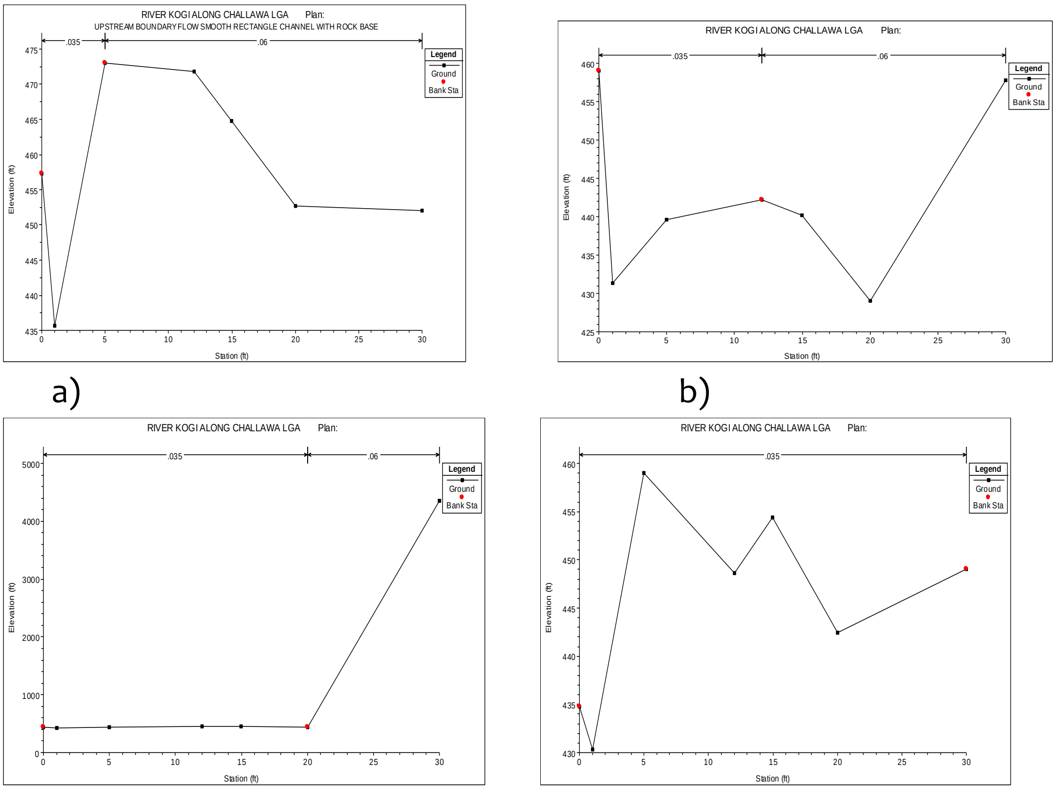


Figure 3: River cross-section cut lines:
a) on the watershed; b) before interpolation

Fig 4: Cross-section plots in HEC-RAS Model



c) d)

Fig 4: Cross-section plots in HEC-RAS Model: a) at River Station 1; b) at River Station 5; c) at River Station 12;
d) At River Station 20
Source: Data analysis for Hec-Ras software 2021

Water Surface Elevation

Water surface elevation for the different discharges fixed at the upstream. It increases with discharges. For given discharge, water surface is constant from cross section 20 to cross section 12 due to a very low value of the free surface slope and it decreases quickly from cross section 5 to cross section 1 due to a high value of the free surface slope. Water surface elevation is sensitive to deformation of 0.06 slopes at the bottom (appendix 1)

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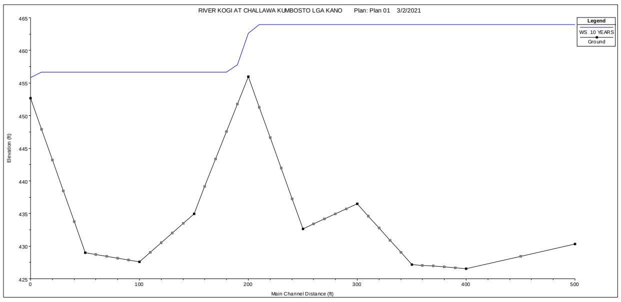
Fig 5 Surface elevation



Source: Data analysis for Hec-Ras software 2021

Energy Grade Elevation

The study area and water surface flow along the smooth channel show a rapid change in the energy of the water surface at cross-section, at station 1 and 5 with is located at the Upstream it was observed at the overbank water is moving fast and may be closer to the energy grade elevation with an increase in discharge will increase the water surface elevation. At station 12 the flow from the upstream moving downstream to station 20 show a wider overbank with a rapid smooth flow which closer to the energy gradeline due to the fact surface water will run up to an elevation

Fig 6 Energy grade elevation

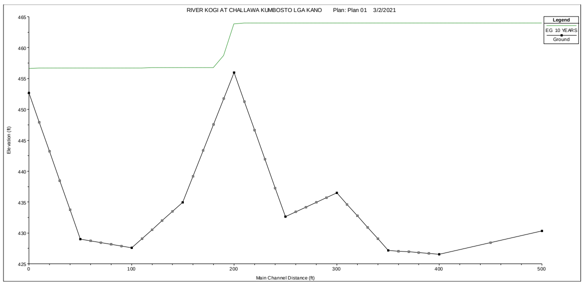


Fig 6 a) Energy grade level for of the watershed before simulation b) after simulation

Source: Data analysis for Hec-Ras software 2021

Critical Depth

When flow regime becomes subcritical or supercritical to reach a critical depth when modeling the watershed for the study area it was observed it a subcritical flow which correspond to the water surface as a result in the significant change in the topography and due to environmental

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factors with to the from upstream to downstream at elevation with critical waster surface 463.83meters with a flow area of 11.33meter and a width 4.83meters (fig 7) with hydraulic jump at the downstream, but when ran and simulated in HEC-RAS for 10 years is show an hydraulic jump at downstream.

Fig 7 Critical Depth

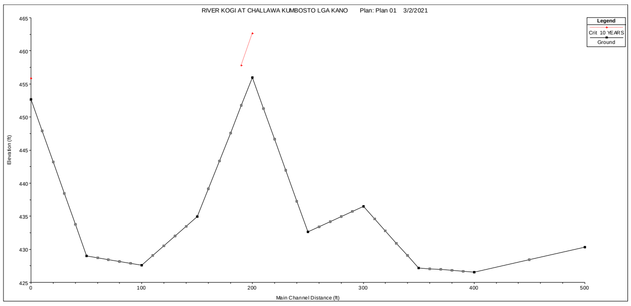

Figure 7: Showing critical depth a) normal b) after interpolation and simulated for 10 years

Source: Data analysis for Hec-Ras software 2021

Velocity

Velocity increases with slopes for given stream flow. Low slopes correspond to low velocities (from upstream to cross section 1 to 5). In these cross sections, the river flow power, the flow is at the highest velocity is observed at cross sections 8 to 12 due to change in the topography. In this section slope is more important but flow area is smaller. Thus, the variations of flow velocity are due to the significant changes in the topography of the river bed and the roughness coefficient effect

Fig 8 Velocity distribution

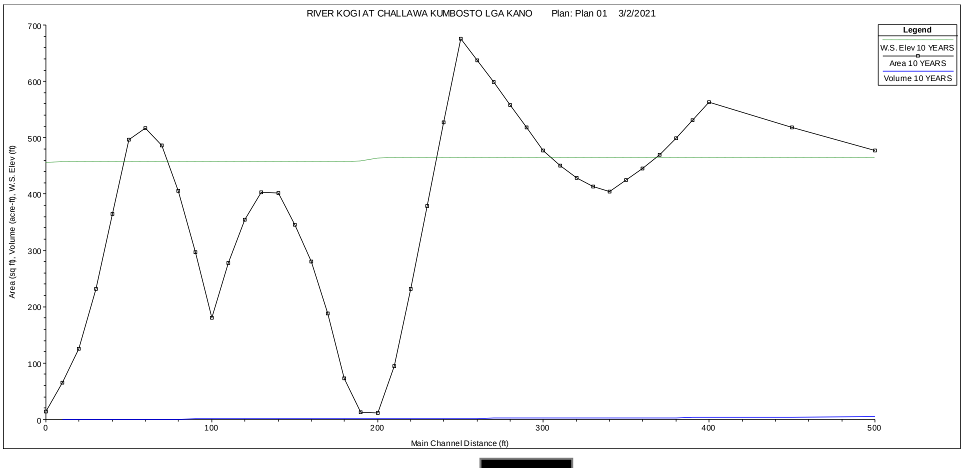

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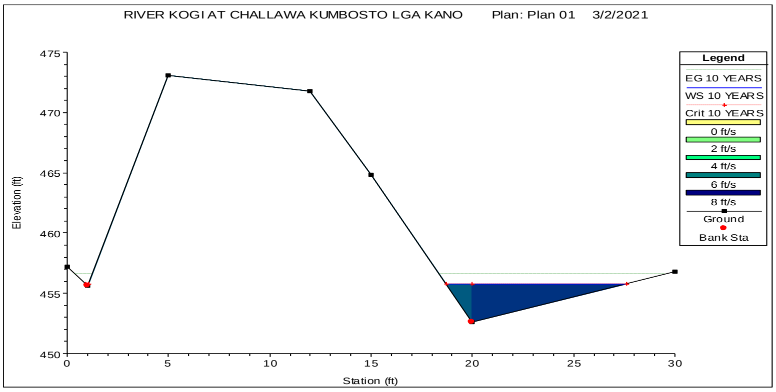
Fig 8: Showing Velocity distribution a) normal b) after interpolation and simulated for 10 years

Source: Data analysis for Hec-Ras software 2021

Model of the watershed

It is been observed that the total volume increases with discharge. For given stream flow, the volume decreases slowly from upstream to downstream. Which show significant changes across the study area, it was seen after running the simulation to show for simulation of 10 years using the software, there is a hydraulic jump for the surface of the water from the upstream to downstream for a subcritical flow as in (Fig 11) which show changes in the energy grade level and critical depth

Figure 9 : cross sections after running the simulation model of the watershed



d) At River Station after interpolation and running the model for 10 years

Figure 10: after interpolation and running the model for 10 years

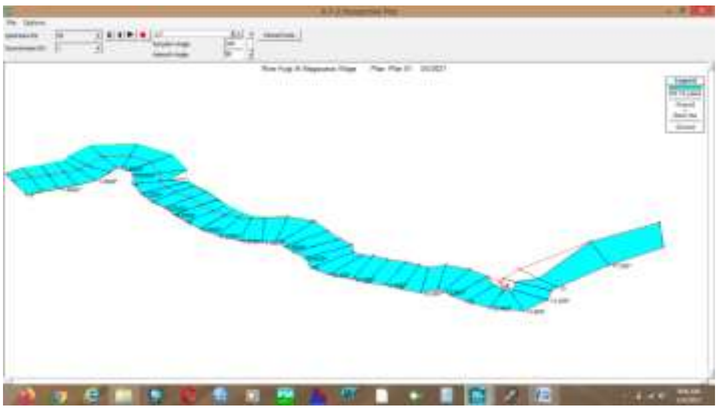


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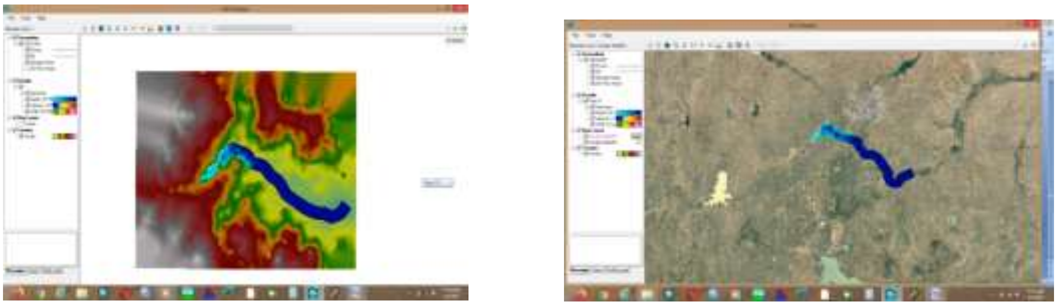
Fig 11: The study area watershed after interpolation and running the model

a) b)



SUMMARY AND CONCLUSION

SUMMARY

The study examine the use of Geo-hydrological survey of the simulation of rainfall runoff process of a steady-state flow using Hec-Ras and Geo-Hec-Ras along river Kogi in magasaw local government area of Kano state, the study was carried out to provide a baseline information on the principles that can be used for watershed management.

As a result of the study a some section of the cross sectional areas along the watershed show significant changes in the topography that rainfall runoff causing high flow from the upstream to the downstream as it indicates potential areas for runoff process with minimum water holding capacity.

Along the watershed it show at each cross section the width increase at the left over bank and right over bank areas, at the right over bank areas show an increase in width which identifies an increase in the water surface level causing erosion the can affect the boundaries of the watershed leading to flood.

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CONCLUSION

Once flow of natural water flow is interrupted there is a massive loss that is incurred. Among these is alteration or loss of habitat and overall disruption of ecosystem. This study analyzes the dynamic of the flow of river Kogi in challawa LGA in Kano. The area of the watershed of this river is selected to develop irrigated cultivation practices, Hec-ras model was used to calculate the main flow characteristics along the study reach to better understand the hydraulic behavior of this river. This allows identifying the Upstream and Downstream flow characteristics areas such as flow velocity, depths, slopes, surface, volume, energy grade level and their Critical depth along the river reach. The large and narrow width areas have been identified. The analysis of the results shows that the most of the Rainfall runoff decreases from upstream to downstream. These

Results give a basis for reflection for decision makers to better understand the river Kogi system and optimize water resources management for an application to the irrigation. However, it is important to recognize the limitations of Hec-ras models. In this approach, the flow is supposed to be channeled while the natural flow.

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