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MAPPING SURFACE HYDROLOGICAL PATTERNS IN THE SOUTHERN PART OF NIGER STATE FROM DIGITAL ELEVATION MODEL

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Abstract

Determination and mapping of the morphometric parameters of a drainage channel is an essential task for water quality assessment, flood modelling and flood prevention; since these parameters affect catchment flow pattern and eventually drain-basins. The SRTM Digital Elevation Model covering Southern Part of Niger State was used to determine the drainage channels, drainage basins and topographic wetness index (twi) around the study area as a surrogate to flood vulnerability in the area. The results obtained from the study identified Shiroro drainage basin (1104.045 Km^2) and Mashegu / Borgu (151.516 Km^2) as the largest and smallest basins respectively in the study area. It also pointed out the possibility of flood in certain Local Government Areas (areas with high wetness index such as Paikoro, Chanchanga, Borgu and Mashegu).

Keywords: Morphometry, Topographic wetness index, Flooding, QGIS

Introduction

The problem of flooding in recent times has received much attention by government and environmental scientist. Considering its severe and devastating effects on lives and properties, flooding is the most frequent form of natural disaster in Nigeria. Though most cases of flood inundation have occurred in the Southern Western and Eastern parts of the country, the North Central region has also recently witnessed her own share of the menace; with flood occurrences in Kogi, Nassarawa and Benue States.

In a bid to mitigate flood occurrence, the importance of locating natural runoff flow routes and documenting them in map form for sustainable planning and development of the urban and rural areas cannot be over emphasized (Chukwuocha and Igbokwe, 2014). These natural drainage channels serve as runoff paths along which water bodies flow on the topographic surface. Once the drainage channels are determined, other hydrological parameters such as catchment area, catchment slope, catchment height and drainage basin can efficiently be delineated. These hydrological parameters therefore serve as indices for efficient design and building of reliable state-wide flood prevention structures and environmental-friendly urban designs. A flow transport channel is principally a function of surface topography and gravity. While it is not the interest of this research to investigate gravimetric impact on natural drainage patterns, the concept of topography in drainage path delineation is herein considered; which requires that a digital elevation model (DEM) of the study area be acquired. Recent advancement in remote sensing technology have improved the methods and processing for developing hydrological models (both graphically and mathematically) to mitigate flood disaster. As remote sensing precisions and accuracies have improved over the years, Digital Elevation Models (DEMs) have gone from 30 – 100 meter resolution to 1 – 5 meter resolution presently for most parts of the Earth's Land Surface (Wallis et al,

2009). Besides, the global-extent coverage and easy on-line accessibility of high precision DEM's are beginning to give its use great popularity and relevance in large scale regional projects and researches. Terrain analysis based on digital elevation models are therefore being increasingly used in hydrology (Wilson and Gallant, 2000). Ajibade et al, (2010) conducted morphometric analysis of the Ogunpa and Ogbere drainage basins in Ibadan based on data derived from a topographic map of the study areas. The study further revealed that morphometric properties of Ogunpa drainage basin are likely to induce high magnitude flood compared to morphometric properties of Ogbere drainage basin. Also, Rao et al (2009) integrated GIS and remote sensing to demonstrate the dynamic equilibrium in the geo-hydrological characteristics of four sub-water sheds of Agra district. This research however used the SRTM 30 arc seconds DEM for Southern Nigeria (Path 189, Row 53) to determine the channel flow patterns, drainage basins and topographic wetness index for the southern part of Niger State in North Central Nigeria.

Process description

Demarcation of Channel Networks
Generally, developing a flow model and mapping the channel network from a gridded Digital Elevation Model follows a now-well- rehearsed procedure (Wallis et al 2009) of (1) filling Sinks (2) computing flow directions and (3) computing the contributing area draining into each grid cell; all which are well described in details by Odumosu et al (2014). The pour point method of pit removal was used for filling the sinks while the Rho 8 method was used for computing the flow direction.

Determination of Drainage Basins:
A drainage basin or watershed is an extent or an area of land where surface water from rain and melting snow or ice converges to a single point at a lower elevation, where the waters join another waterbody, such as a river, lake, reservoir, estuary, wetland, sea, or ocean (www.wikipedia.com). Determination of Drainage basins is fundamentally done using the Strahler's technique (Strahler, 1957; Hajam et al, 2013) wherein the conglomerate of $1^{st} - 4^{th}$ order streams (drain channels) are linked together to form a basin as shown in Figure 1.

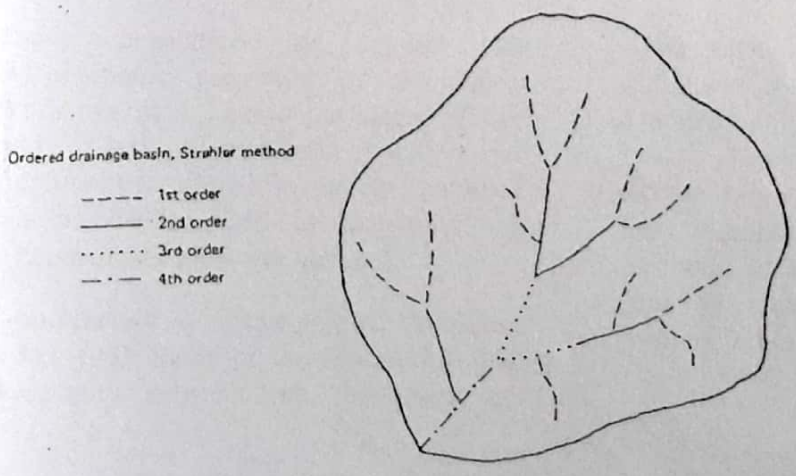

Figure 1: Ordering of Drainage channels in stre*ams*. Adapted from Morisawa (1964)