

Remote sensing and Geographical Information System using for Water Resources Management for Bandama Watershed (Côte d'Ivoire): Case study of Kohoua Subwatershed at Farandougou

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Abstract— Nowadays, studies on water resources management are quite important. This study on a subwatershed of the Bandama River in Côte d'Ivoire got a better understanding of the geomorphological characteristics of the study area. The use of satellite images and geographic information systems tools allowed to respond appropriately the management of water resources. The Digital Elevation Model (DEM) of the Farandougou subwatershed, the Bandama river hydrographic network and the geostatistical analysis of this subwatershed have been shown and interpreted in this study. The area's elevation is between 0 and 700 meters approximatively. The value of river length minimum is around 11273.091 meters and the value of river length maximum is around 44415.180 meters, the coefficient of variation is around 0.462 for example. The geostatistic of Kohoua at Farandougou has given also mean of 449.621 meters, mediane of 441 meters, variance of 3040.996 meters and standard deviation of 55.145 meters. The majority of the Kohoua subwatershed area has an elevation around 410 meters versus the minority around 715 meters.

Keywords— Geomorphological, Bandama, satellite, river, elevation.

I. INTRODUCTION

The Bandama River Basin, fully located in Côte d'Ivoire, occupies an area of 97 500 km² between 3°50' and 7° West and 5° and 10°20' North. Because of its North-South orientation, it covers so different areas on the climatic and biogeographical [14]. The length is about 1050 km with an average annual flow of 263 m³.s⁻¹ at city of Tiassalé located at the south of Bandama watershed at the north of Abidjan the economic capital. The main affluent of the Bandama River are Marahoué (or Red Bandama, 550 km), Solomougou, Bou, Badénou, Lokpoho, N'zi. It flows into the Atlantic Ocean, through

the Gulf of Guinea, south of Nzida (Lagoons region, south of the country), and 105 km west of the city of Abidjan (economic capital of the country, and the most populated city in French-speaking West Africa). View the effects of climate change and problems related to lack of water in aquifers. Côte d'Ivoire must conduct studies for the management of water resources in its watershed and subwatersheds. Our study will focus on the Kohoua sub-basin located in Farandougou northwest of the Bandama River. There are no many studies for this area which covers an area about 630 Km² and a specific flow of 11.1 l/s km².

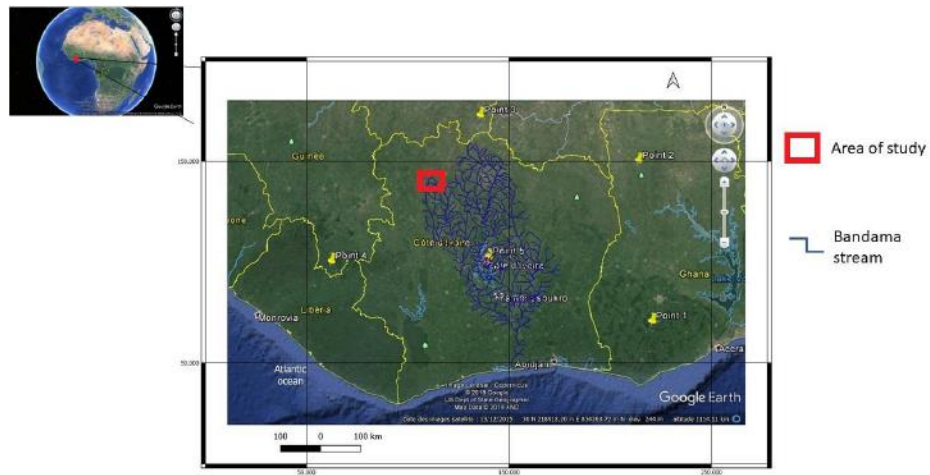


Fig. 1: Localization of the study area with Google Earth

II. MATERIAL AND METHOD

Digital Elevation Model (DEM) is the digital representation of the land surface elevation with respect to any reference datum. DEM is frequently used to refer to any digital representation of a topographic surface. DEM is the simplest form of digital representation of topography (Balasubramanian, 2017). We use four DEM (ASTGTM2_N08W007; ASTGTM2_N008W008; ASTGTM2_N09W007 and ASTGTM2_N09W008). We download the DEM from the National Aeronautics and Space Administration (NASA) website

<https://urs.earthdata.nasa.gov/>. We need to know exactly the position of our area of study. We use also the software QGIS 3.0.1 for the treatment of the DEM for the hydrological interpretations.

III. RESULTS

We get the DEM of Farandougou after treatments and analyses. This DEM show that elevation in Farandougou is between 0 and 700 meters.

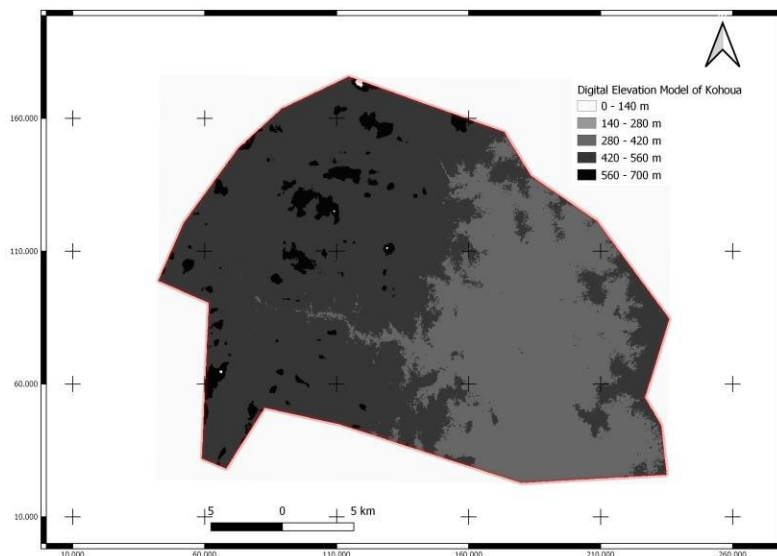


Fig. 2: Digital Elevation Model DEM of Kohoua at Farandougou

The GIS tools allow us to know more about watersheds and are useful for management of water resources in general. We show also the flow of water in Kohoua subwatershed at Farandougou.

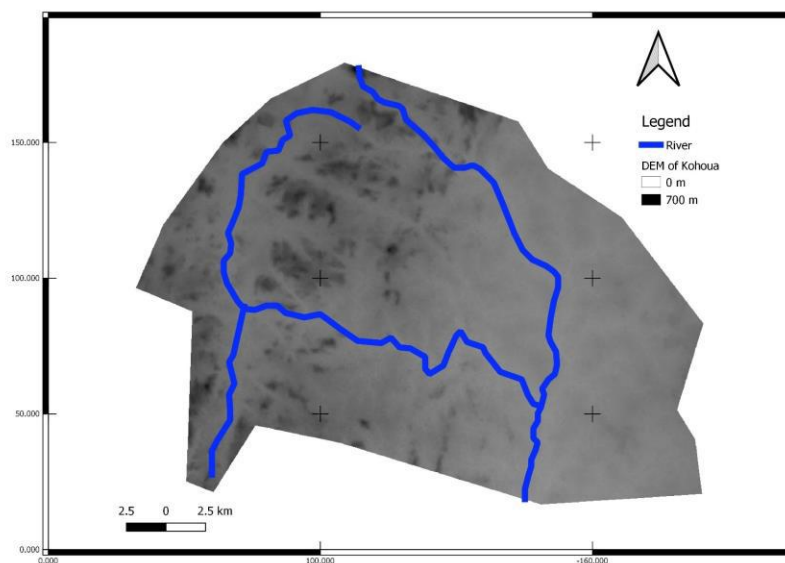


Fig. 3: Hydrological network of Kohoua at Farandougou

It is important to have information on the flow of water, the streams direction in this subwatershed. All these informations are necessary to manage water resources. We also obtain another map combining the DEM information and the hydrographic network.

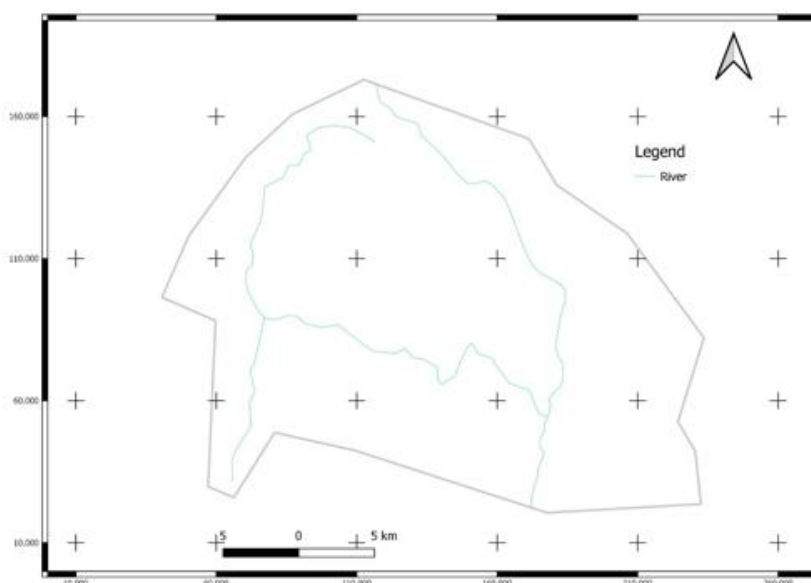


Fig. 4: DEM and hydrological network

As the authors have noted in the past, hydrologic process and water resource issues are commonly investigated by use of distributed watershed models. These watershed models require physiographic information such as configuration of the channel network, location of drainage divides, channel length and slope, and subcatchment geometric properties. Traditionally, these parameters are obtained from maps or field surveys. Over the last two decades this information has been increasingly derived directly from digital representations of the topography ([11]; [6]; [9]; [15]).

The digital representation of the topography is called a Digital Elevation Model (DEM). The automated derivation of topographic watershed data from DEMs is faster, less subjective and provides more reproducible measurements than traditional manual techniques applied to topographic maps [5]. Digital data generated by this approach also have the advantage that they can be readily imported and analyzed by Geographic Information Systems (GIS). The technological advances provided by GIS and the increasing availability and quality of DEMs have greatly expanded the application potential of DEMs

to many hydrologic, hydraulic, water resources and environmental investigations [9]. We get also the histogram of the DEM that shows the subwatershed of Kohoua in Farandougou .

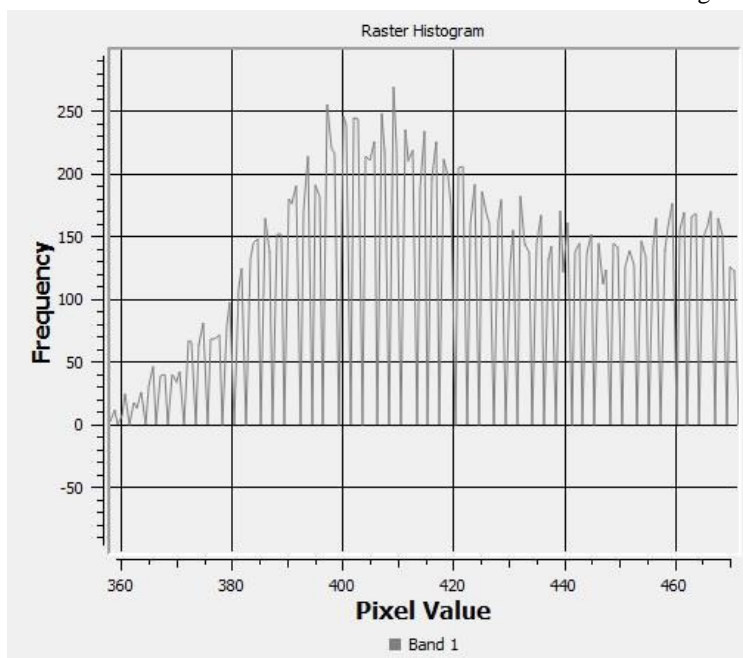


Fig. 5: Histogram of DEM

We get also the statistics on the river that give more detailed information about river.

TABLE. 1: Table of river statistic in meter

Analyse field	Count	Unique values	NULL missing values	Minimum values	Maximum values	Range
Length (Meter)	3	3	0	11273.091	44415.180	33142.088

TABLE. 2: Continuation of TABLE 1

Sum	Mean value	Median value	Standard deviation	Coefficient of variation (without unit)	Minority	Majority
90445.937	30148.646	34757.666	13917.179	0.462	11273.091	11273.091

TABLE. 3: Continuation of TABLE 1

First quartile	Third quartile	Interquartile Range (IQR)
23015.379	39586.423	16571.044

TABLE. 4: Table of geostatistical on Kohoua subwatershed at Farandougou in meter

Count	Sum	Mean	Median	Standard deviation	Minimum
736808	331284396	449.621	441	55.145	0

TABLE. 5: Continuation of TABLE 4

Maximum	Range	Minority	Majority	Variety	Variance
807	807	715	410	446	3040.996

IV. DISCUSSION

Several studies on Bandama subwatershed show many characteristics like the flow measured and the hydrological characteristics (The official document from Hydrological Directory of Côte d'Ivoire, 1969). But we see that there is a lack of new work and data in this field concerning the management of water resources. Our study subwatershed shows some similarity with another subwatershed close to it called Lokpoho and located between the cities of Ferkessédougou and Korhogo. The subwatershed of Lokpoho is bigger with area of 1200 km². The twice has a maximum flow around 55 m³/s and a minimum measured flow measured around 0.01 m³/s. This study helps us to know topography and the wetlands that is quite good for water resources management in agriculture. The remote sensing and GIS tools lead to have data like DEM and make many treatments with software QGIS 3.0.1. Although, high resolution DEMs are generally very cost effective and relatively accurate, there is inherent uncertainty in the products (e.g. vertical accuracy usually below 1 m), which may be deemed insufficient for certain hydrological applications (European Space Agency, Water Resource Management EO4SD). GIS is used to determine the potential for occurrence of groundwater and thus participates in their better management within the states (Intermap Website, <https://www.intermap.com>, 2016). According to many analysis and studies, the wetlands are important for the hydrogeology. The wetlands are good indicator of groundwater because the wetlands use the groundwater to survive. So, wetlands are groundwater dependant Ecosystems.

We know in our study the elevation and we can now trying to get exactly this wetland and their groundwater in them. Some can also assume that the groundwater elevation is the same as the wetland's elevation in our basin.

We explain that by the fact that in dry season, the river may not be full and groundwater table in the river is close to the bottom. Also, we have the phenomena of recharging and discharging in our basin. It is important to note that sometimes not all the basin network recharging and discharging, it's just 1/3. However, in low relief landscapes, the resulting DEMs often display systematic east-west striping patterns that can make them unsuitable for parameterization of drainage features [17]. And then, drainage paths are systematically biased in the east-to-west direction because of flow draining into and following the artificial elevation stripes. Finally, the striping may introduce drainage blockages in the north-to-south flow component. These drainage blockages can

produce artificial depressions of varying sizes. The source of the striping is a combination of human and algorithmic errors associated with the manual profiling method (USGS, Mid Continent Mapping Center). While these "striping" errors are well-recognized [17], they are within the accuracy standards of the USGS (1990). The predominance of pits and flat areas in the valley bottoms (low relief areas) are clearly visible. Pits are usually viewed as spurious features that arise from interpolation errors during DEM generation and truncation of interpolated values on output [16]. Pits are a major difficulty for DEM evaluation methods that rely on the overland flow simulation approach to drainage analysis because a lack of downslope flow paths leads to incomplete drainage pattern definition. The drainage identification problems for flat areas are similar to those encountered for pits.

V. CONCLUSION

This study shows that remote sensing with satellite images gives can permit to know more about the water resource in a watershed. In Africa, particularly in Côte d'Ivoire the management of water resource is very important because many people don't have access to pure water. It is important to use some Geographical Information Systems tools like the software Quantum Geographic Information Systems (QGIS) for the management of watershed.

This original study will be a model for many others on the Bandama river subwatersheds.

We note that DEMs are often processed by GIS packages to define the configuration of the channel network, location of drainage divides, channel length and slope, and subcatchment properties. The automated derivation of such information from DEMs is faster, less subjective and provides more reproducible measurements than traditional manual evaluation of maps.

Past trends and developments, the increasing quality and resolution of new DEM products, new raster processing methodologies, as well as the expanding capabilities of GIS and linkage with traditional watershed models, lead us to believe that the use of DEMs to derive topographic and drainage data for water resources investigations will continue to increase.

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