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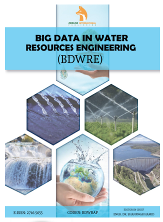

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RESEARCH ARTICLE

RAINFALL CHANGE DETECTION IN AFRICA USING REMOTE SENSING AND GIS BETWEEN 1999 – 2018

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ABSTRACT

Many researchers used gauge data from weather stations for rainfall estimate across Africa. Since Africa lies within the tropics, there is possibility for variations in rain received from place to place. Therefore, there is need for excessive density of the gauges for accurate estimate of Africa's rainfall. Due to numerous challenges, these cannot be achieved. This necessitates the application of remote sensing and GIS to detect changes in rainfall amount in Africa between 1999 and 2018. The data used was obtained from remote sensing satellite (TRMM) and analyzed using GIS application (IDRISI Taiga). The Simple Image Differencing was performed on the two annual mean images covering January to December, 1999 and January to December, 2018. This provides reliable information on rainfall estimate that can complement sparsely and unevenly distributed rain gauge network in Africa. The analysis shows that latitudinal locations, to some extent, determine spatial distribution of rainfall in Africa. It is also observed that significant changes in rainfall rate are mainly found around coastal regions. It was recommended that adequate ground data it needed to confirm these findings. African countries should provide adequate and justly distributed weather stations with on-net database for easy access to the data.

KEYWORDS

Rainfall, Africa, Remote Sensing, GIS, Image Differencing.

1. INTRODUCTION

Collins English Dictionary defines rainfall as the amount of rain that falls in a place during a particular period. The distribution of the world's rainfall is shifting as our climate changes. Wet areas may become wetter, dry areas drier, storms more intense, leading to more chaotic weather around the world (Precipitation Measurement Missions, 2020). In Africa, An average of less than 1,000 millimeters of rain falls per year across most of Africa. Rainfall tends to decrease with distance from the equator. The variability of rainfall from annual average is greater in a region that gets little precipitation (Thornton, 2014). Most researchers used gauge data from weather stations for rainfall estimate across Africa (Nicholson et al., 2018; Nicholson et al., 2012; Nicholson et al., 2000; Gizaw and Gan, 2016). Since Africa lies within the tropics, there is possibility for variations in rain received from place to place as described (Ratnayaka and Johnson, 2009). Therefore, there is need for excessive density of the gauges for accurate estimate of Africa's rainfall. Due to poor land terrain, difficult accessibility, multiple administrative and political settings, time consuming and financial constraints, the weather stations with rain gauges cannot adequately be provided. The ultimate solution to these challenges is remote sensing and Geographical Information Systems (GIS) application for rainfall data acquisition and analysis. Sequel to the advancement of remote sensing and GIS technology in geospatial analysis, this research adopted it to monitor rainfall changes in Africa from 1999 to 2018. Choice of 1999 as the start date was because the Tropical Rainfall Measuring Mission (TRMM) satellite that provides the rainfall data was launched in orbit in 1998, therefore unavailable data before that date.

2. MATERIALS AND METHODS

2.1 The Study Area

Africa is the second largest continent (after Asia), covers about one-fifth of the total land surface of Earth. The continent is bounded on the west by the Atlantic Ocean, on the north by the Mediterranean Sea, on the east by the Red Sea and the Indian Ocean, and on the south by the mingling waters of the Atlantic and Indian oceans. Africa's total land area is approximately 11,724,000 square miles (30,365,000 square km), and the continent measures about 5,000 miles (8,000 km) from north to south and about 4,600 miles (7,400 km) from east to west. The continent is cut almost equally in two by the Equator, so that most of Africa lies within the tropical region, bounded on the north by the Tropic of Cancer and on the south by the Tropic of Capricorn (McMaster et al., 2020).

The movement of air masses and their effects provide the basis for a

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division of the Africa continent into eight climatic regions. These are the hot desert, semiarid, tropical wet-and-dry, equatorial (tropical wet), Mediterranean, humid subtropical marine, warm temperate upland, and mountain regions (McMaster et al., 2020). The current population of Africa is 1,325,585,480 as of Wednesday, January 15, 2020, based on the United Nations estimate which is equivalent to 16.72% of the total world population (Worldometer, 2020).

Figure 1: The Study Area (Africa) (Source: McMaster et al., 2020)

2.2 Data Collection

The rainfall data (3B43v7) on 0.25^{0}x 0.25^{0} resolution is a product of Tropical Rainfall Measuring Mission (TRMM) satellite. The two (2) remotely sensed images (1999 and 2018) were downloaded via Giovanni tool at annual mean (January-December) as Time Average Maps on NASA's website (https://giovanni.gsfc.nasa.gov). The data has passed through all the necessary corrections by the data management body. The downloaded data was on GeoTIFF format which was imported and converted to Idrisi Raster format. To find out spatio-temporal changes in rainfall rate that occur between 1999 and 2018 in Africa, Simple Image Differencing was carried out using IDRISI software, the Taiga edition and the results were presented.

3. Results and Discussion

The first image (a) on Figure 2 is an annual mean rainfall rate from January to December, 1999 (called Africa 1999). The second image (b) is a corresponding image for 2018 (called Africa 2018). The palette was automatically selected by the software used. From visual observation on the two images, though slight variations in terms of spatial distribution exist, higher amount of rainfall were observed around the equatorial regions. This shows that latitudinal location affects rainfall distribution in Africa (Abdullahi et al., (2019); Integrated Climate Data Center – ICDC, 2019; Kaptué et al., 2015).

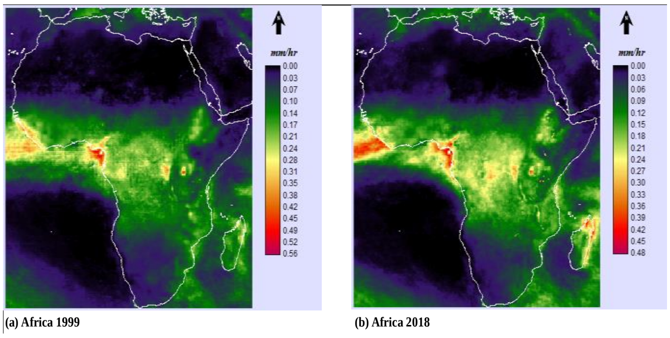

Figure 2: Annual mean of Rainfall rate in Africa (Source: Adapted and modified from NASA, 2020)

Using Thresholding, the upper and lower limits to variation was established. This helps to isolate the true change from change image (called Change). This was achieved using HISTO and RECLASS modules (Figure 3). The Image Differencing technique identifies areas of positive and negative changes of rainfall rate in Africa between 1999 and 2018. The result shows that Gulf of Guinea, Mozambique and coastland between Dakar and Monrovia experiences decrease in rainfall. Conversely, areas around Republic of the Congo and Northeastern Madagascar experiences increase in quantity of rainfall. Generally speaking, the observed changes occur around the land-ocean borders. This event was attributed to climate change that causes dynamic consequences on ocean current (warm and cold) as suggested by University of Texas, (2018).

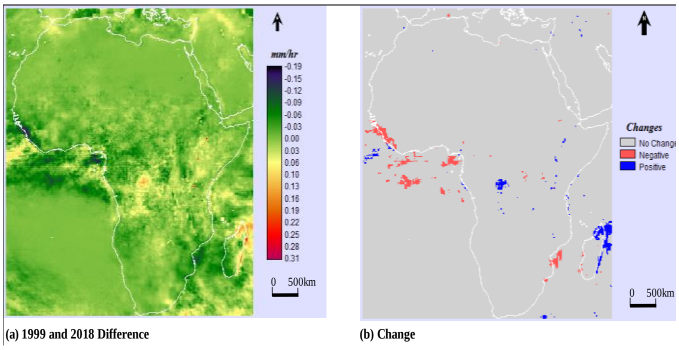

Figure 3: Rainfall dynamics in Africa (Source: Adapted and modified from NASA, 2020)

The regression analysis on two images shows that the second image has strong relationship with the first image with strong linearity (r = 0.93) and coefficient of determination (r^2 = 87.43%). This assumed that the later image is a function of earlier one. This denotes the accuracy of the change detection analysis as described on Image Differencing analysis.

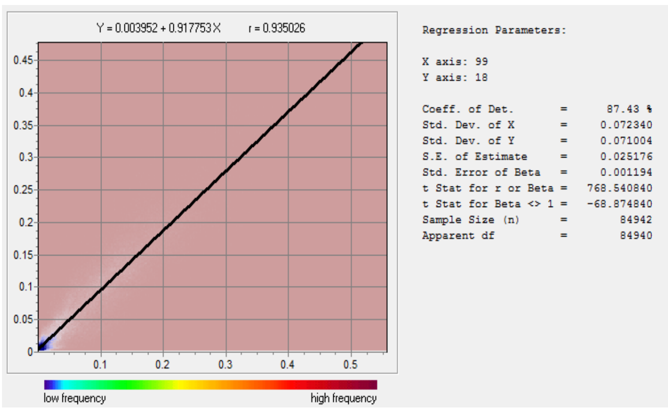

Figure 4: Regression Parameters (Source: Author's Analysis (2020)

4. Conclusion and Recommendations

This research adopted the use of remote sensing for the observation of rainfall distribution in Africa that appeared in form of raster images. The obtained images were later subjected to spatial analysis using GIS

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software (IDRISI Taiga). This process assists to overcome the challenges a researcher may encounter during in obtaining rainfall data from ground weather stations. The analysis shows that latitudinal locations, to some extent, determine spatial distribution of rainfall in Africa. It is also observed that significant changes in rainfall rate are mainly found around coastal regions that signify effect of climate change on the ocean currents and the adjacent lands. It was recommended that adequate ground data it needed to confirm these findings. African countries should provide adequate and justly distributed weather stations with on-net database for easy access to the data.

Acknowledgment

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