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Geo-spatial Analysis of Farmland Affected by 2020 Flooding of River Rima, Northwestern Nigeria

Abdullahi Muktar[1*], Sadiq A. Yelwa[1], Muhammad Tayyib Bello[2] and Wali Elekwachi[3]

[1]Department of Geography, Usmanu Danfodiyo University, Sokoto State, Nigeria.
[2]Department of Civil Engineering, Usmanu Danfodiyo University, Sokoto, Nigeria.
[3]Department of Geography, University of Nigeria Nsukka, Enugu State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author AM designed the study, collect data and perform spatial analysis. Authors SAY and MTB make corrections on the final draft. Author WE managed the literature review. All authors read and approved the final manuscript.

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ABSTRACT

The flooding of River Rima is an annual issue affecting farmland located within the floodplains. This phenomena causes loss of farm produce and mass destruction of buildings, including roads and bridges in the area. Estimating the farmland affected by the flood will help the policy makers in decision making on how to mitigate the impact of flooding in the affected areas. The Terra/MODIS satellite image with 7-2-1 bands combination was used to classify the image into four landcover types. The area covered by flood was selected to calculate the flood area using Image Calculator module on QGIS software. The class of water was imposed on Digital Elevation Model that was obtained from Environmental Monitoring Satellite called The Shuttle Radar Topography Mission (SRTM). The result shows that River Rima flood occupies about 17,517 km2, equivalent to 1.7 million hectares of farmland that is below 230 meters (ASL). It was recommended that the local authorities and decision makers may use the flood map to showing flood risk zones so as to deter construction beyond the buffer. Farmers should adhere strictly to NiMet's advice based on flood predictions. The civil engineers should also take note of the maximum water level during flooding so as to apply professional advice when constructing roads and bridges in the area.

**Corresponding author: Email: abdullahimuktar21@gmail.com;*

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1. INTRODUCTION

Asituation when there is too much water, the flow capacity of creeks or rivers (known as waterways) become overwhelmed and burst their banks, flooding areas which are not normally under water. This is called riverine or main channel flooding [1]. Riverine flooding is caused by bank overtopping when the flow capacity of rivers is exceeded locally. The rising water levels generally originate from heavy snowmelt or high-intensity rainfall creating soil saturation and large runoff - locally or in upstream catchment areas. Sudden dam breaks or embankment failures are also important causes of flooding, and the severity may be further increased by local rising groundwater after prolonged natural recharge [2].

The number of people living close to rivers and within floodplain areas are growing rapidly worldwide and recent years have proven a significant increase in frequency and severity of flood events in river systems globally. This creates a major threat to a growing number of people and their property [2]. According to Floodlist [3], thousands of homes and wide areas of crops have been destroyed in 2020 flooding in the states of Jigawa, Kano, Kebbi and Sokoto in northern Nigeria. As many as 30 people are thought to have died. Similarly, The National Emergency Management Agency (NEMA) on its 2020 flood report stated that at Kende in Kebbi State, the Rima River stood at 5.03 meters as at 30 August. The Rima joins the Niger River just south of Kende. At the Jidere Bode measuring station in Kebbi rose from 1.4 meters in mid July to 5.74 meters by late August, 2020.

The THISDAY Newspaper of September 9, [4] reported that six lives were lost and thousands of hectares of rice farmland were destroyed in Kebbi state. A statement from the presidency put estimated losses at about N10bn and the President in a September 6, 2020 tweet expressed his dismay while putting the flood disaster in context: "I am particularly saddened by the Kebbi flooding disaster, which has led to the loss of lives and destruction of thousands of hectares of farmland. It is a major setback to our efforts to boost local rice production as part of measures to end importation. This bad news couldn't have come at a worse time for our farmers and other Nigerians who looked forward to a bumper harvest this year in order to reduce the current astronomical rise in the costs of food items in the markets.

In search of the area covered by the flood, a Geospatial technique is adapted using remotely sensed data and application of Geographical Information System (GIS) for the analysis. GIS integrates many types of data and analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes. With this unique capability, GIS reveals deeper insights into data, such as patterns, relationships, and situations—helping users make smarter decisions [5]. On the other hand, USGS [6] defines Remote sensing as the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers sense things about the Earth. By applying these approaches, wider extent of land is observed at a glance and makes spatial analysis on the target area with minimum bias. Some researchers that applied remote sensing and GIS in this direction include Abdullahi and Yelwa [7]; Abdullahi and Yelwa [8] and Adrian [9].

This research aimed at identifying the extent of land being affected by the 2020 flooding along River Rima axis that cut across Sokoto and Kebbi States. The results will serve as the warning against building structures within the affected areas, and advise the farmers to make use of the identified area for rice production as the area is now considered a floodplain. To reduce human error during data collection and analysis, geospatial technique was adapted. Geospatial Technique, according to American Association for the Advancement of Science [10], is the ability to assemble the range of spatial data into a layered set of maps which allow complex themes to be analyzed using computer and then communicated to wider audiences. This 'layering' is enabled by the fact that all such data includes information on its precise location on the surface of the earth.

2. MATERIALS AND METHODS

2.1 Location of the Study Area

River Rima is the main river channel on Sokoto-Rima River Basin, located at the Northwestern

Nigeria. The river cut across Zamfara, Sokoto and Kebbi States. The river is also a tributary to River Niger. Apart from Bakolori, Goronyo and Zobe dams, the river sources its water from other minor river channels that include Gulbin Maradi, Bunsuru, Gagare, Sokoto, Gaminda and Zamfara [7,8]. The region of the River Rima covered by this study is geographically located between Latitudes 11.15^0 and 13.95^0; and also between Longitudes 3.59^0 and 6.27^0 (Fig. 1).

2.2 Physical Geography of the Study Area

The River Rima, according to Ifabiyi and Ojoye [11,12] falls within the Sudano-Sahelian Zone of Nigeria with fluctuation in mean annual rainfall and number of rainy days. Umar et al. [13] described that larger population in the region relied on rain-fed farming for their livelihoods. Therefore, any changes in rainfall characteristics could adversely affect their livelihoods. This rainfall trend has a great impact on the hydrological cycle and therefore affects both the quality and quantity of water resources. Similarly, Abdulrahim et al. [11] discovered that there is an increasing trend of rainfall amount in the area and also seasonality in monthly precipitation showed a concentration of rainfall in the months of June, July and August while it decreases in September; however, the months of March, April, and October do experience some showers of rainfall sometimes. The months of January, February, March, April, May, November and December are dry months.

The vegetation of the area is considered Sudano-Sahelian that is characterized by vast grassland with scattered woody vegetation found around the flood-plains. Small plants, usually grasses, shrubs, and small trees dominate the landscape of semi-arid regions. Certain plants in semi-arid regions may have some of the same adaptations as desert plants, such as thorny branches or waxy cuticles to reduce evaporation and water loss through their leaves [14]. The area generally contains unconsolidated sediments conveyed by running water and wind. These are accumulations of organic matter, sand, gravel, loam, silt, and/or clay, and are often important aquifers. They are found in the floodplains of the Rima Basin. This type of soil provides a good ground for farming [15].

2.3 Data Collection and Analysis

The data used was observation from Terra/MODIS satellite with 7-2-1 bands combination [16]. The two images (pre-flood and flood periods) were dated May 14, 2020 and September 8, 2020 respectively with 250m spatial resolution. The QGIS software was use to classify the September image as this was the period when the flooding was at its peak as adapted from Hussain et al. [17]. The downloaded image of the flood period is 7-2-1 bands composite and was classified into four landcover features (Fig. 2 for flow chart). These are water bodies, bare surfaces, vegetation and clouds using Supervised Maximum likelihood Classification Technique. Since the target feature is areas affected by flood, the class of water bodies was selected and calculates the number of pixels contained using Image Calculator. A class of water bodies was superimposed on Digital Elevation Model (DEM) after conversion to hillshade and contour formats to visualize areas affected by the flood in relation to elevation. The DEM data used was an observation by Environmental Monitoring Satellite called The Shuttle Radar Topography Mission (SRTM). The data have been enhanced by the data provider to fill areas of missing data to provide more complete digital elevation data with a resolution of 3 arc-seconds for global coverage (approximately 90m spatial resolution). The DEM was downloaded via [18]. The area of interest was windowed using IDRISI Taiga to focus on the study area. The result was later converted to area in hectares. Finally, the area covered was then estimated to find out the quantity of rice to be produced if properly cultivated.

3. RESULTS AND DISCUSSION

Due to the sensor resolution (250m), the water on a river channel cannot be detected, but large pools of water such as reservoirs can be seen on the pre-flood image. Those pools of water are pointed using red-doted arrow (Fig. 3a). This shows that even the main river channel is not up to 250 meters wide during pre-flood period. This indicated that farmers have enough space within the valley for cultivation.

The overall Kappa accuracy test for the Classified Image on Semi-Automatic Classification Plug-in (SCP) in QGIS is 0.81. The result of the analysis shows that the width of River Rima extended from less than 250 meters in May, 2020 to an average of 5 kilometers in September, 2020.This means that the river has increased 20 times wider than its usual size.

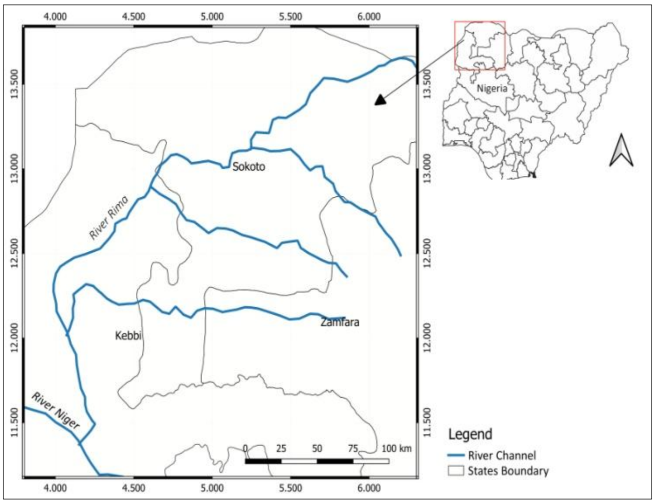

Fig. 1. The study area

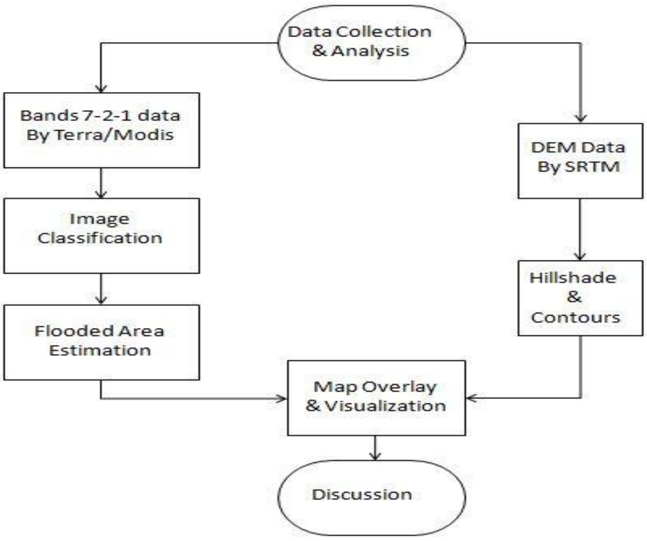

Fig. 2. Methodological flow chart

The flooded fields were mainly rice and millet farms where the crops were destroyed completely as the flood occur before harvesting. Fig. 3b shows that flooded water occupies about 17,517 km^2 which is equivalent to 1.7 million hectares of farmland. According to Grow Crops Online [19], this extent of land, if harnessed properly can produce about 5.2 million tons of rice per single round of production. According to Bamidele et al. [20], this quantity of rice can feed 211 million people per year which is greater than Nigeria's 2020 estimated population.

Fig. 4(a) shows visual impression on the areas affected by the flooding using hillshade format. The lowest elevations contain water using light-blue palette. While Fig. 4(b) describe the land elevation above sea level affected by the flood using contours. It is suggested that the 2020 flood area of River Rima, according to this research, is considered flood hazard zone. Therefore, locating structures around those areas should be avoided.

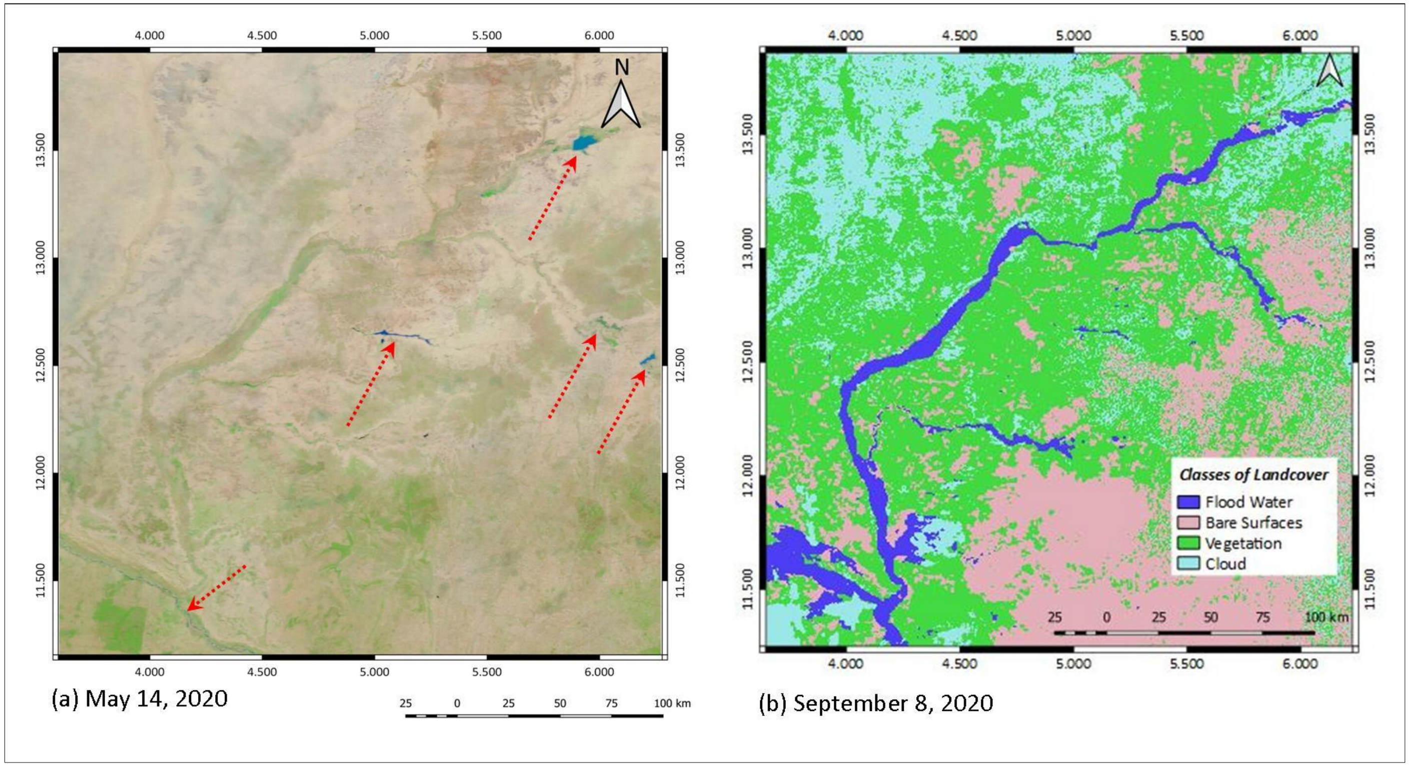

Fig. 3 Pre-flood period and flood periods

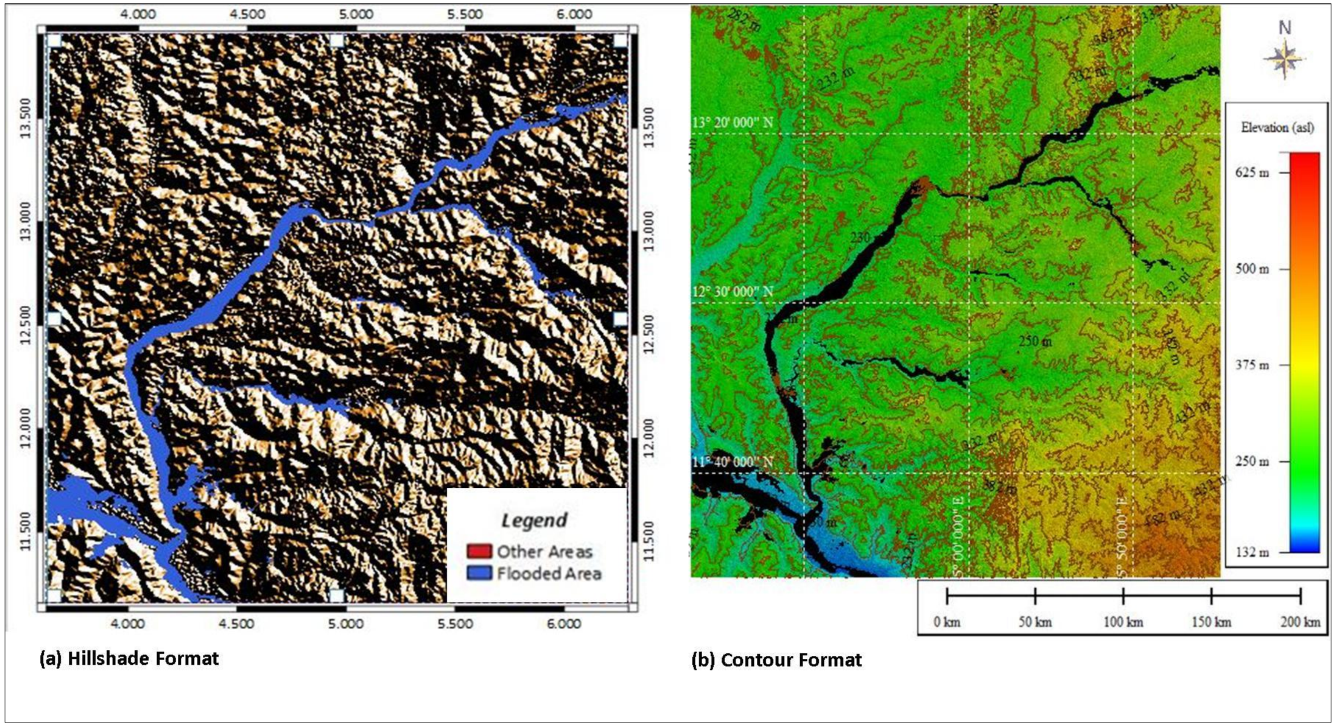

Fig. 4. Flooded area and elevation data

The contours show that locations below 230 meters are completely covered by flood. This result confirm the finding of Abdullahi and Yelwa [6] where some settlements were found to be within the floodplain that include Birnin Kebbi, Ambursa, Dagere, Jawo, Unguwar Sani, Makera, Maurida, Unguwar Kayi, U. Mijin Nana, Unguwar Gero, Kola, and Wuro Maliki using Map Overlay. Similarly, Sadiq et al. [21] observed that water from River Benue overflow hundreds of farmlands and destroyed crops in the region.

4. CONCLUSIONS AND RECOMMENDATIONS

With the application of geospatial technology, images of the target area were collected remotely, analyzed and information presented. The 2020 flood of River Rima occupies about 17,517 km^2 which is equivalent to 1.7 million hectares of farmland. This extent of land contains both crops and human settlements where they are affected negatively. The flooded area, according to this research is considered flood hazard zone, therefore building structures within the area, if necessary, should be elevated to an altitude above 230 meters (ASL).

The high resolution imagery can help to detect crops mostly affected by the flood. It is recommended that farmers should adhere strictly to NiMet's advice based on flood predictions so as to prevent lost of properties and livelihood. The local authorities and decision makers may use the flood map to indicate flood risk zone to serve as a barrier for buildings and dwellers. Civil engineers should also take note of the maximum water level during design, construction and supervisions stages, to avoid flood disaster in the floodplain and to use the reconnaissance survey of the locality during any road & bridge works. If hydrological and environmental knowledge are considered when executing projects, loss of lives and property will be minimized during flood.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Flood Victoria. Riverine Flooding; 2020. Accessed: December 15, 2020 Available:https://www.floodvictoria.vic.gov.au/learn-about-flooding/flood-types/riverine
2. MIKE by DHI. Riverine Flooding; 2020. Accessed:December 15, 2020 Available:https://www.mikepoweredbydhi.com/products/mike-flood/riverine-flooding
3. Floodlist. Nigeria – Floods Destroy Crops and Homes in North; 2020. Accessed:December 15, 2020 Available:http://floodlist.com/africa/nigeria-floods-jigawa-kano-kebbi-september-2020
4. Thisday Newspaper of September 9. Floods and Sadiya Farouq's Warnings; 2020. Accessed:December 15, 2020 Available:https://www.thisdaylive.com/index.php/2020/09/09/floods-and-sadiya-farouqs-warnings/
5. ESRI. What is GIS? 2020. Accessed: December 15, 2020 Available:https://www.esri.com/en-us/what-is-gis/overview
6. USGS. What is remote sensing and what is it used for? 2020. Available:https://www.usgs.gov/
7. Abdullahi M, Yelwa SA. An analysis of the flood-prone areas in Birnin Kebbi, Using Remote Sensing and GIS. Journal of Geography, Environment and Earth Science International 2020a 24(6):77-85. ISSN: 2454-7352. Accessed:January 27, 2021. Available:https://www.journaljgeesi.com/index.php/JGEESI/article/view/30237/56759
8. Abdullahi M, Yelwa SA. Birnin kebbi urban expansion between 1990 and 2019: A threat to available agricultural land. Journal of Agricultural Economics, Environment and Social Sciences. 2020b;6(1): 95 – 102. ISSN: 2476 – 8423. Accessed: January 2020b 28, 2021
9. Adrian R. Flood hazard monitoring using GIS and remote sensing observations. Carpathian Journal of Earth and Environmental Sciences. 2017;12(2):329-334.

Available:https://www.researchgate.net/publication/313579335_FLOOD_HAZARD_MONITORING_USING_GIS_AND_REMOTE_SENSING_OBSERVATIONS
10. American Association for the Advancement of Science, What are geospatial technologies; 2021.
Accessed: January 27, 2020
Available:https://www.aaas.org/programs/scientific-responsibility-human-rights-law/overview-geospatial-project
11. Abdulrahim MA, Ifabiyi IP, Ismaila A. Time series analyses of mean monthly rainfall for drought management in Sokoto, Nigeria. Ethiopian Journal of Environmental Studies and Management. 2013;6(5).
Available:http://dx.doi.org/10.4314/ejesm.v6i5.3
12. Ifabiyi IP, Ojoye S. Rainfall trends in the sudano-sahelian ecological zone of Nigeria. Earth Science Research. 2013;2(2).
E-ISSN: 1927-0550.
DOI:10.5539/esr.v2n2p194
13. Umar AT, Mashi SA, Bako MM. Investigation of Rainfall Characteristics in Sudano-Sahelian Region of Nigeria (1971–2006). In: Leal Filho W. (eds) Handbook of Climate Change Resilience. Springer, Cham; 2020.
Available:https://doi.org/10.1007/978-3-319-93336-8_165
14. Moll E. What Is a Semi-Arid Climate? sciencing.com; 2018.
Available:https://sciencing.com/semiaridclimate-10009421.html
Accessed: January 27, 2021.
15. Sombroek WG, Zonneveld IS. Ancient dune fields and fluviatile deposits in the Rima-Sokoto river basin (N.W. Nigeria): Geomorphologic phenomena in relation to Quaternary changes in climate at the southern edge of the Sahara. Wageningen Univercity and Research;1971.
Available: https://edepot.wur.nl/304272.
Accessed: January 27, 2021.
16. NASA; 2020.
Available:https://wvs.earthdata.nasa.gov/
17. Hussain E, Kim K, Shan J. Object–based image classification and web-mapping techniques for flood damage assessment. ASPRS 2009 Annual Conference. Baltimore, Maryland. 2009
Accessed:December 14, 2020
Available:
https://www.asprs.org/a/publications/proceedings/baltimore09/0039.pdf
18. Glo Vis; 2020.
Available:https://glovis.usgs.gov/app
19. Grow Crops Online. Rice Fully Booked; 2018.
Accessed: on December 14, 2020
Available:https://www.growcropsonline.com/crops/view/15-rice
20. Bamidele FS, Abayomi OO, Esther OA. Economic analysis of rice consumption patterns in Nigeria. Journal of Agricultural Science & Technology. 2010;(12):1-11.
Accessed:December 14, 2020:
Available:https://nairametrics.com/wp-content/uploads/2013/02/Economic-Analysis-of-Rice-Consumption-Pattern.pdf
21. Sadiq AA, Abdullahi M, Ardo AU. Assessment of post flood impact on farmlands along river benue floodplains of yola and environs. International Journal of Scientific and Research Publications. 2019;(9)2:679-691.
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