Landsat-8 Satellite Data for Geological Mapping of Plateau State, North Central Nigeria

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ABSTRACT:

We are living in an evolving planet that has been transforming for a long period of time and it continuous to. The earth surface and under is made up of Rocks, Sediments, Minerals and many more. The representation of these features graphically is the geological map. The use of remote sensing satellite data has been greatly employed in the past decades to produce and update these maps, which are always a pre-requisite for interpretation, discrimination of rocks, sediment, and soil units. In this study, Landsat-8 image data was used to produce an updated geological map of Plateau state, north central Nigeria that has scarcity of it. Four scenes of Landsat-8 satellite image data were processed and mosaicked into a composite image, and the boundary line of the state was superimposed on the composite image in the ArcGIS environment (Figure 2). An RGB colour composite of bands (7, 5, and 3) and Band ratio (7/4, 6/5 and 5/3) of the VNIR and SWIR bands of Landsat-8 were used to reveal vegetation, lithological units, and hydrothermal alteration zones. The consequence of the study is the identification of predominant biotite granitic rocks that are distributed along the Jos-Bukuru complex and underlying almost half of the entire state. Moreover, the other rock complexes such as basalts and rhyolitic volcanic rocks were also discriminated. This study indicates that Landsat-8 image data has great capability to discriminate lithological units and the production of up-to-date geological map of Plateau state, Nigeria at regional scale and could be applicable in other regions of the African continent.

1. Introduction:

The geological map is an architectural representation of the ground surface and underneath, which allows us to make the most out of our resources, providing us information about minerals, oil, coal and etc. And to locate water that is filtered into the aquifers as well as geothermal energy resources. Geological maps also, provide vital informations that guide agricultural activities and to have adequate knowledge about where natural occurrences are likely to take place including landslides, earth quakes, floods, and volcanic eruptions and minimizing their catastrophe (Rowan, 1974).

The remote sensing approach began with the use of pairs of aerial photographs which were viewed under mirror stereoscopes to allow for 3 dimensional views of the surface of the earth and prepare preliminary maps for geological studies and out of them were accurate positioning and pointing's of folds, faults and classification of materials. Today, satellite data have replaced the use of stereoscopes, and reduced facial traverses in the field, nevertheless, when they are combined with field and geophysical measurements the output becomes usually very accurate for geological discriminations. However, the technology of remote sensing would still require that the signals who record and capture the information necessarily must reach the ground surface making the process simpler when the region in question is arid in nature with characteristics of sparse vegetative cover. Tropical and heavily forested areas pose a lot more treat to optical data images (Pour and Hashim, 2011b).

The advantage of applying the use of Landsat-8 a multispectral image is due to its capacity at the Visible and Near-Infrared as well as shortwave infrared bands which enables a clear identification of changes in soils and the differentiation of rock outcrops. Also, the advantage of being a modern digital design with fewer moving parts when compared with previous Landsat series and, in addition to the on-board GPS that permits it provide accurate positioning while being retroactively improving previous Landsat programs (Landsat 5 & 7 data). The Landsat data has been put to use severally in the production of geological maps [] whose descriptions fall within the visible and the shortwave infrared bands that are recommended to be the best in revealing mineral related informations (Bands 2 through 8).

Today, we have access to digital geological maps in the web that are interactive in electronic documents, but such would only enable earth science issues to be understood in the regional geospatial context. With them, informations about size, shape, depth and physical/chemical contexts of earth materials can be procured. However, they will reveal informations at regional scales. District and local scale geological mapping still take their position, of supplying information to the very mining districts. To blend with the present economic development, scientific investigations and the unprecedented growth of communities, it is essential to keep updating our maps so as to have accurate scientific knowledge of our environments. These maps would be needed by local, state and Federal agencies for sustainable development.

2. Geology of the study area:

Plateau state north central Nigeria is located at lat. 80° 24´N and Long. 80° 32´ and 100° 38´ E of the Greenwich Meridian, covered by an area of 26, 899 square kilometres ably falling within four Scenes of Landsat-8 image of path 187 to 188 and Row 053 to 054 respectively (Fig.1). The Jos Plateau is thought to be an area of younger granite which was intruded through an area of older granite rock, making up the surrounding states. These "younger" granites are thought to be about 160 million years old. This creates the unusual scenery of the Jos Plateau. There are numerous hillocks with gentle slopes emerging from the ground like mushrooms scattered with huge boulders. Also volcanic activity 50 million years ago created numerous volcanoes and vast basaltic plateaus created from lava flows. This also produces regions of mainly narrow and deep valleys and pediments (surfaces made smooth by erosion) from the middle of rounded hills with sheer rock faces. The phases of volcanic activities involved in the formation of Plateau State have made it one of the mineral rich states in the country. Tin is still mined and processed on the plateau (Wikipedia). See figure 2 showing the geological map of mineral deposits in plateau state.

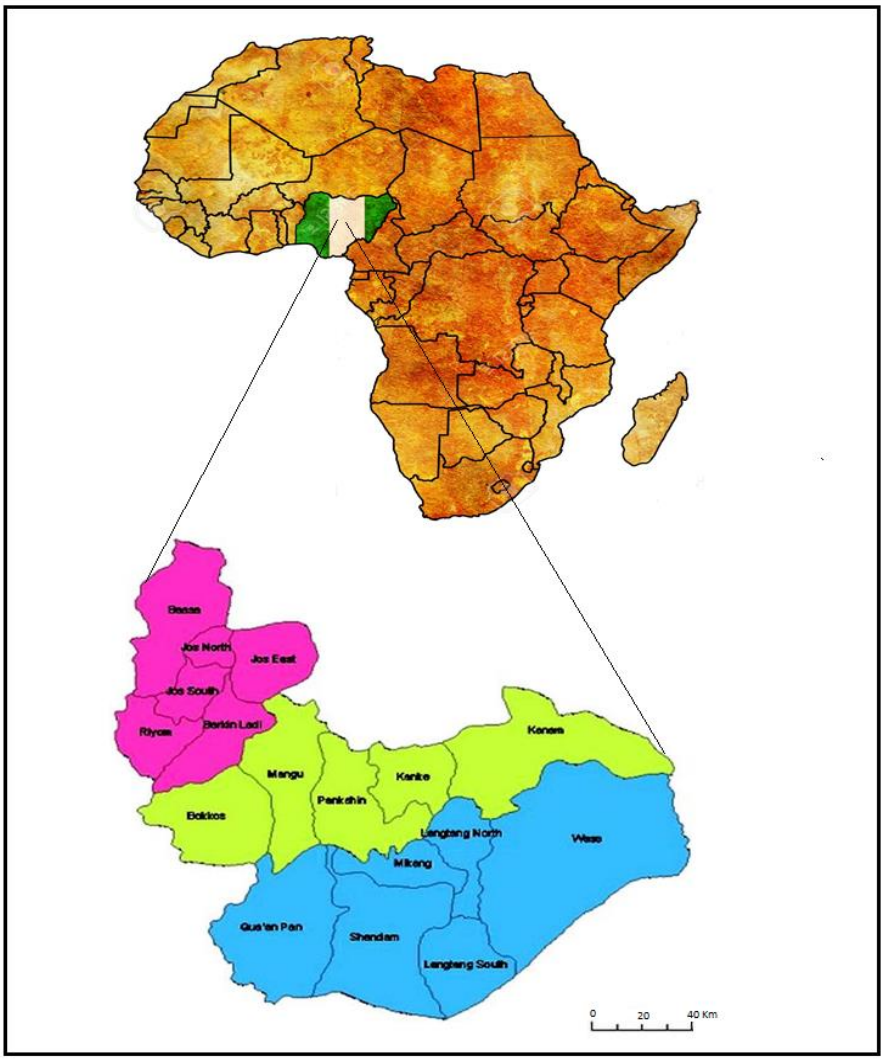

Figure 1 Map of Africa showing study area in Nigeria

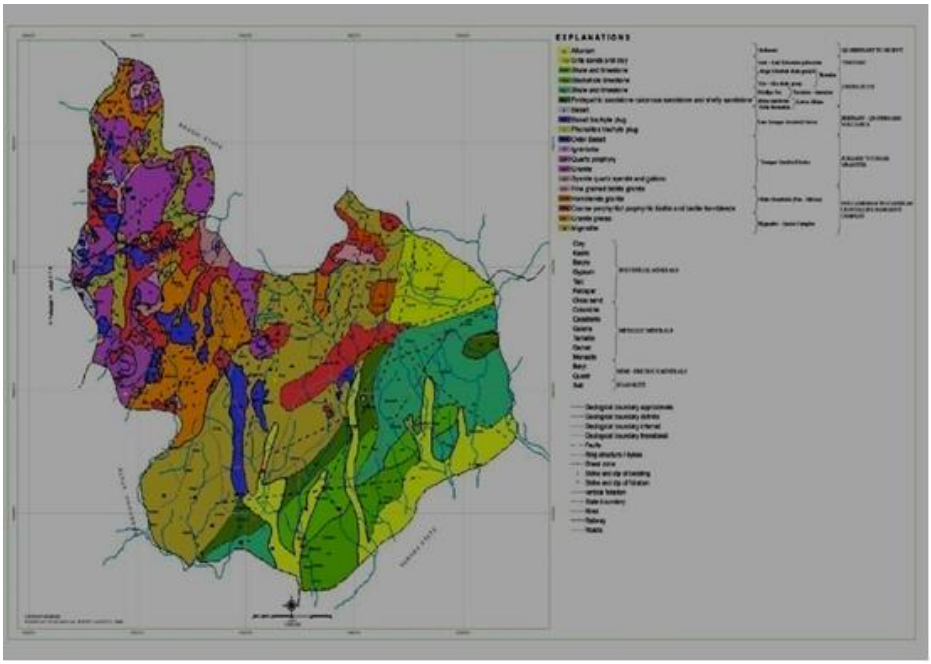

Figure 2 Geological and mineral resources map of plateau state.

2. Materials and methods:

3.1 Materials:

The landsat-8 image data is the new product of the Landsat series from the NASA under the open source and free for download. It has 11 bands that stretch between the visible, near infra-red, and the Thermal regions of the electromagnetic spectrum**.** Landsat 8 is radio metrically more sensitive than earlier Landsat platforms. The spectral signal of it is measured and presented across a much greater range (0.43 – 12.51 um). Earlier imagery were 8 bit giving 256 distinct values from the ground. But Landsat 8 data are quantised to 12-bits before transmission and are mapped to 16-bits for Level 1T data products giving 65,536 distinct values (Drury, 2014).

Table 1 Spectral characteristics of Landsat-8 image data

S/N	BAND	WAVELENGTH (μm)	RESOLUTION (m)
1	Band 1-Coastal Aerosol	0.43 – 0.45	30
2	Band 2 – Blue	0.45 – 0.51	30
3	Band 3 – Green	0.53 – 0.59	30
4	Band 4 – Red	0.64 – 0.67	30
5	Band 5 – NIR	0.85 – 0.88	30
6	Band 6 – SWIR 1	1.57 – 1.65	30
7	Band 7 - SWIR 2	2.11 – 2.29	30

8	Band 8 – Panchromatic	0.50 – 0.68	15
9	Band 9 – Cirrus	1.36 – 1.38	30
10	Band 10 – TIR 1	10.60 – 11.19	100
11	Band 11 – TIR 2	11.50 – 12.51	100

3.2 Methodology:

3.2.1 Remote sensing data

The Landsat-8 image of the study area were downloaded and prepared for digital image processing using ENVI 4.8 and ArcGIS 10.3 software's. Each scene was loaded into The ENVI image analysis program and began to visualize what is in the scene. The data were converted to surface reflectance by the internal average relative reflection method (Lucas, 2014), which is recommended for calibration in mineralogical mapping, and does not require prior knowledge of samples collected in the field. During atmospheric correction, raw radiance data from an imaging spectrometer is re-scaled to reflectance data, and therefore all spectra are shifted to nearly the same albedo. The resulting spectra can be compared directly with laboratory or filed reflectance spectra. Panchromatic and cirrus cloud (band 9) bands were not used in this study.

3.2.2 RGB Band combinations:

Colour composite images for this study area were created to show the classification and distributions of rock types for each image scene, the Near Infrared (NIR) wavelength is one of the most commonly used wavelengths on multispectral sensors because vegetation reflects so strongly in this portion of the electromagnetic spectrum that this information proves very useful when performing vegetation analyses. Each scene was processed through creation of image stack, image pyramid, RGB Composite image creation as follows:

Bands (7, 5 and 3) gave a false colour image composite with an enhanced image with the rocky outcrops shown in shades of purple and blue. Many structural features are visible with good atmospheric penetration, this band combination is similar to the 5, 6, 4 band combination but vegetation shows up in more vibrant shades of green, rock classification and urban areas as well as some kinds of soil to appear as shown in figure (4, 5, 6, and 7). Band 5 measures the near infrared, or NIR. This part of the spectrum is especially important for ecology because healthy plants reflect it – the water in their leaves scatters the wavelengths back into the sky while Bands 6 and 7 cover different slices of the shortwave infrared, or SWIR. They are particularly useful for telling wet earth from dry earth, and for geology: rocks and soils that look similar in other bands often have strong contrasts in SWIR. While band 3 is very useful for discerning differences in bare earth and for telling what is wet and what is dry in a scene. The RGB composites for the four scenes are shown in figures (Pour and Hasim, 2014).

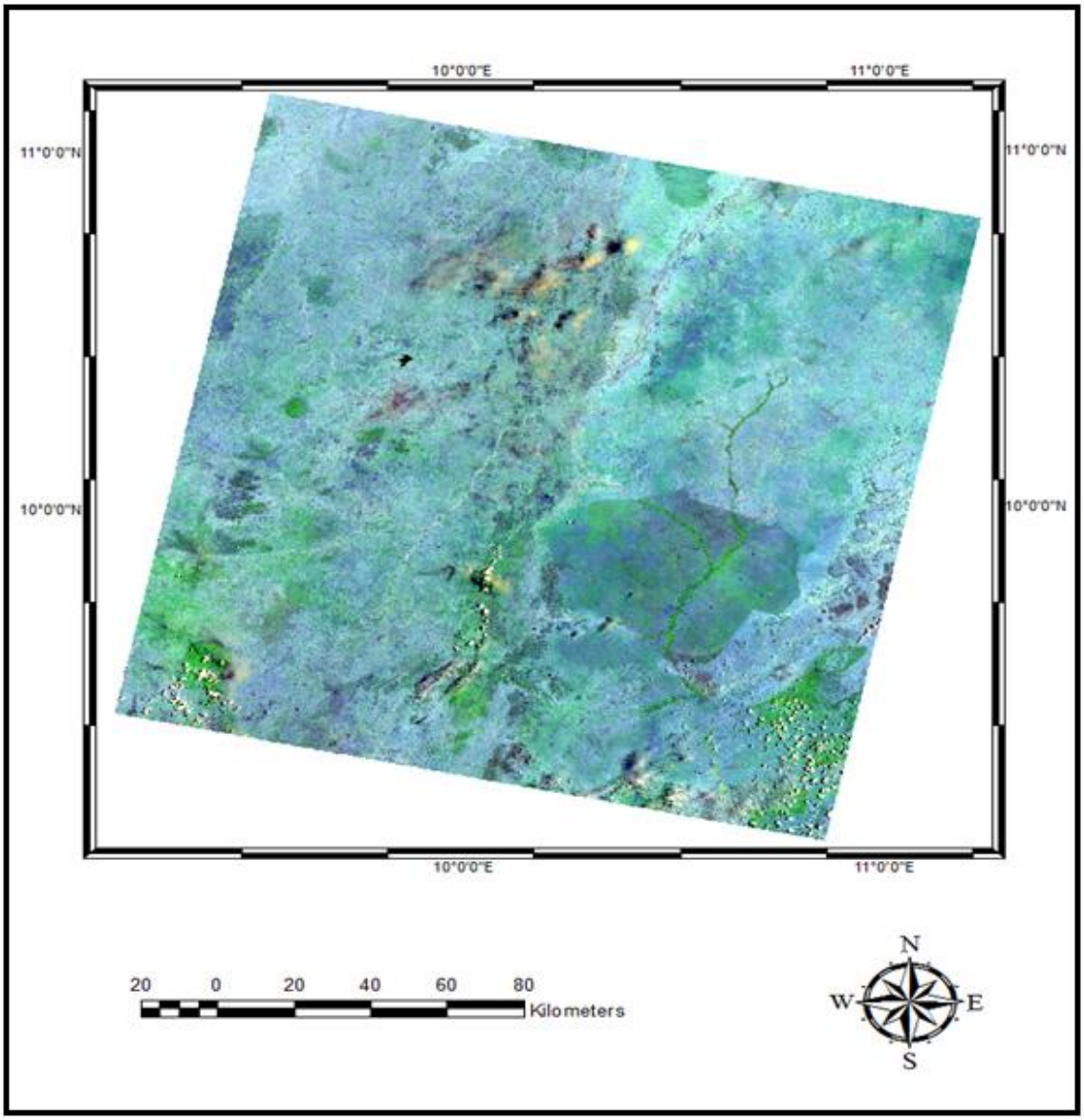

Figure 3: Composite Map of scene one

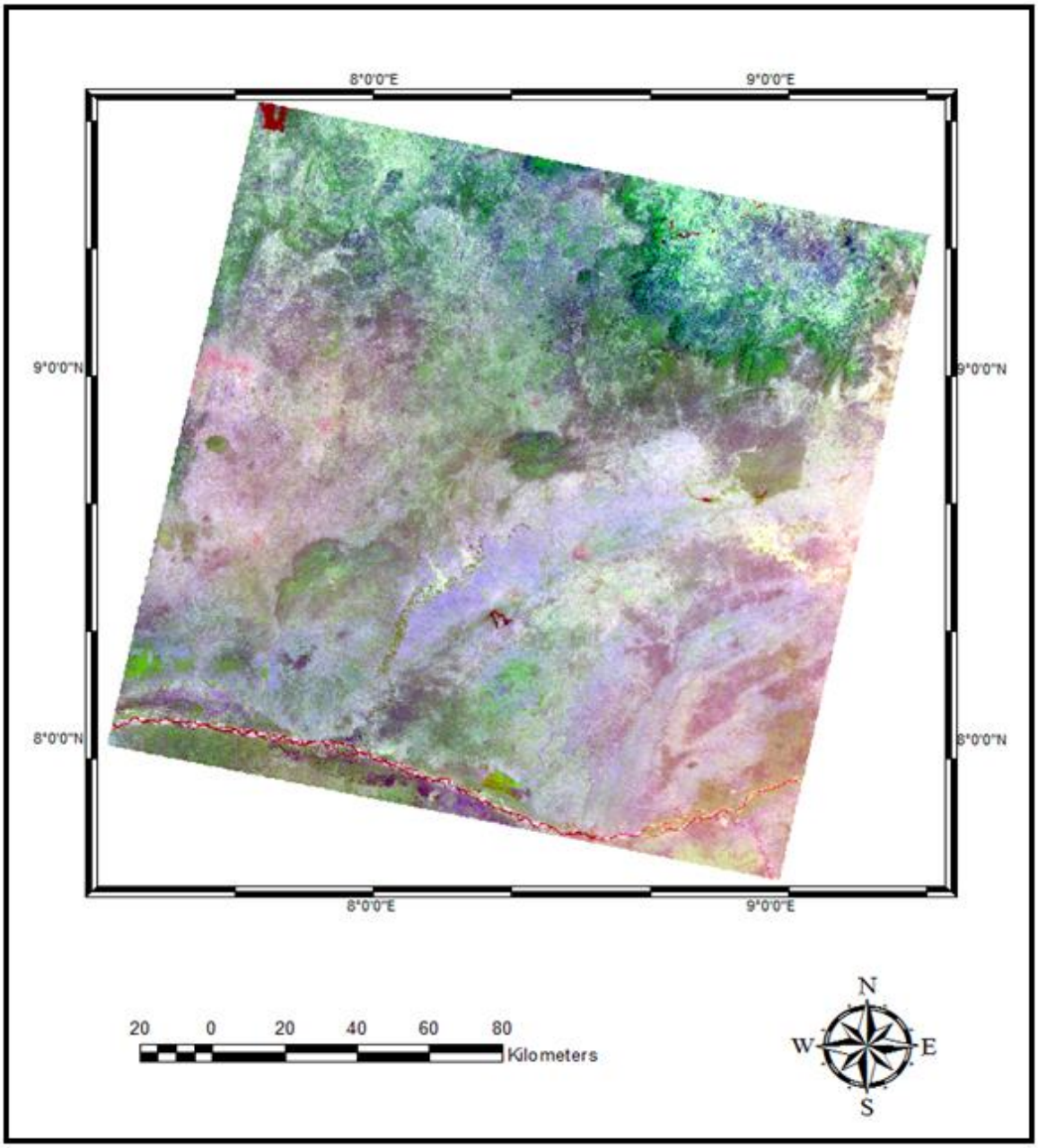

Figure 4: Composite map of scene two

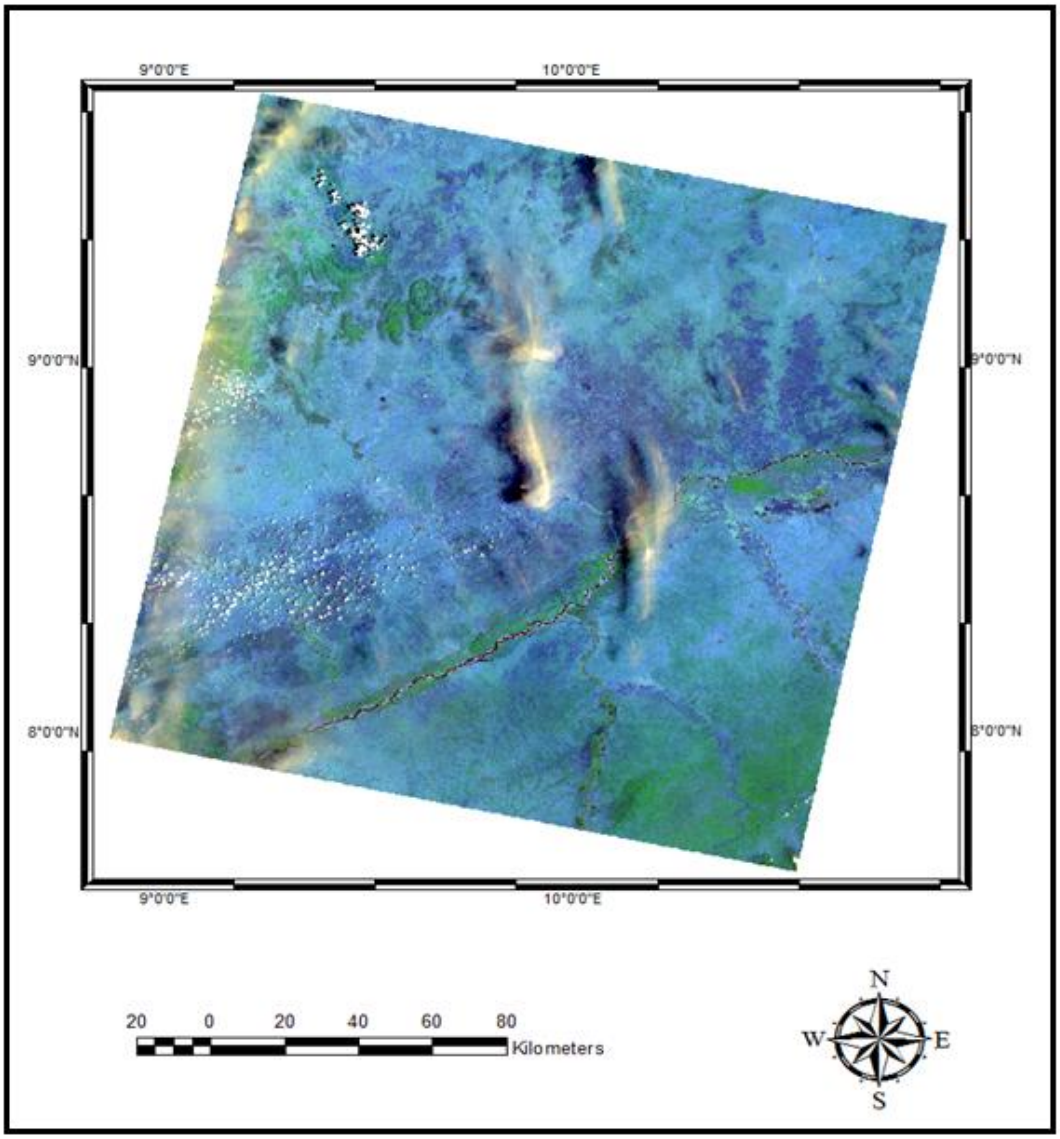

Figure 5: Composite map of scene three

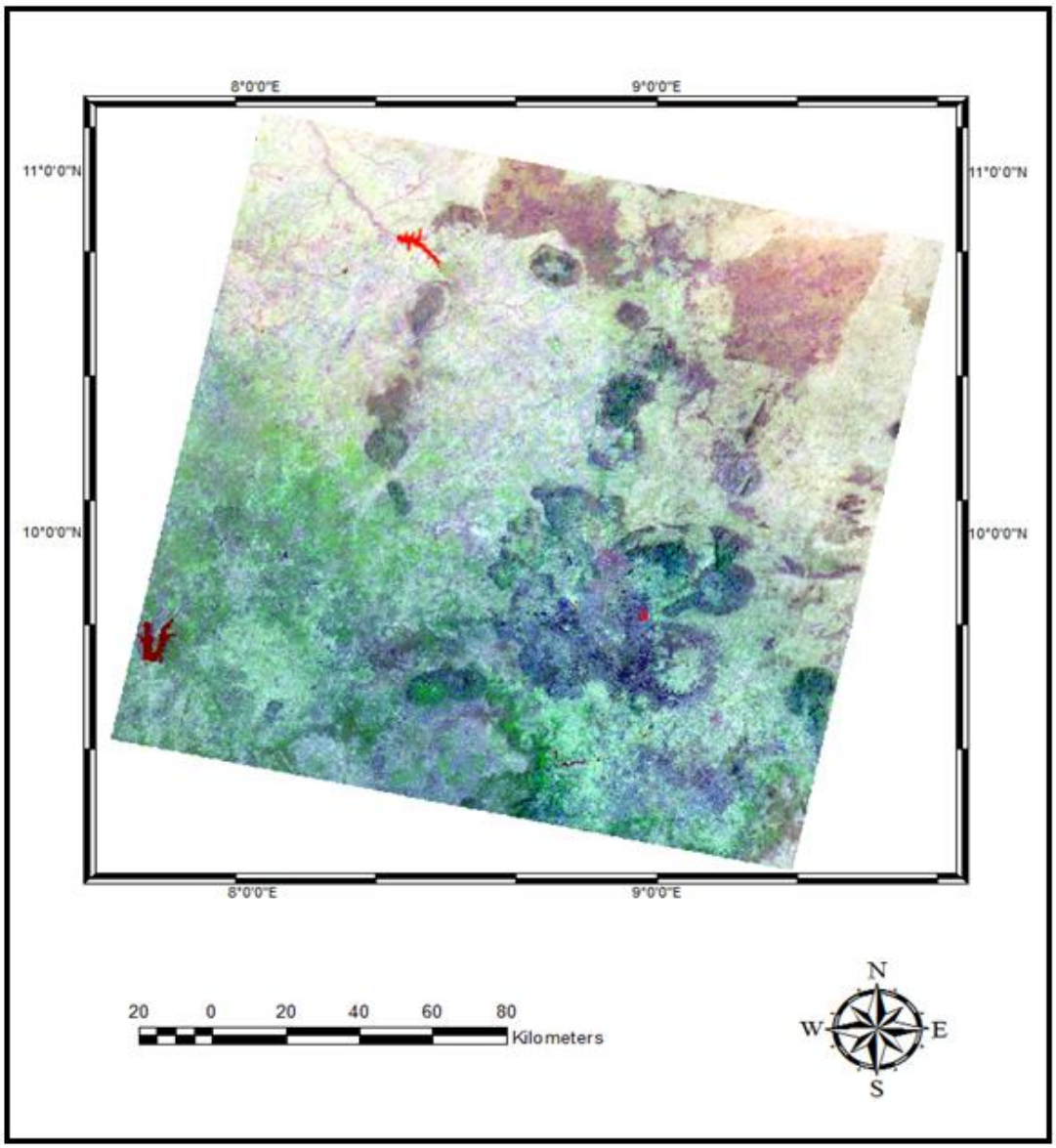

Figure 6: Composite map of scene four

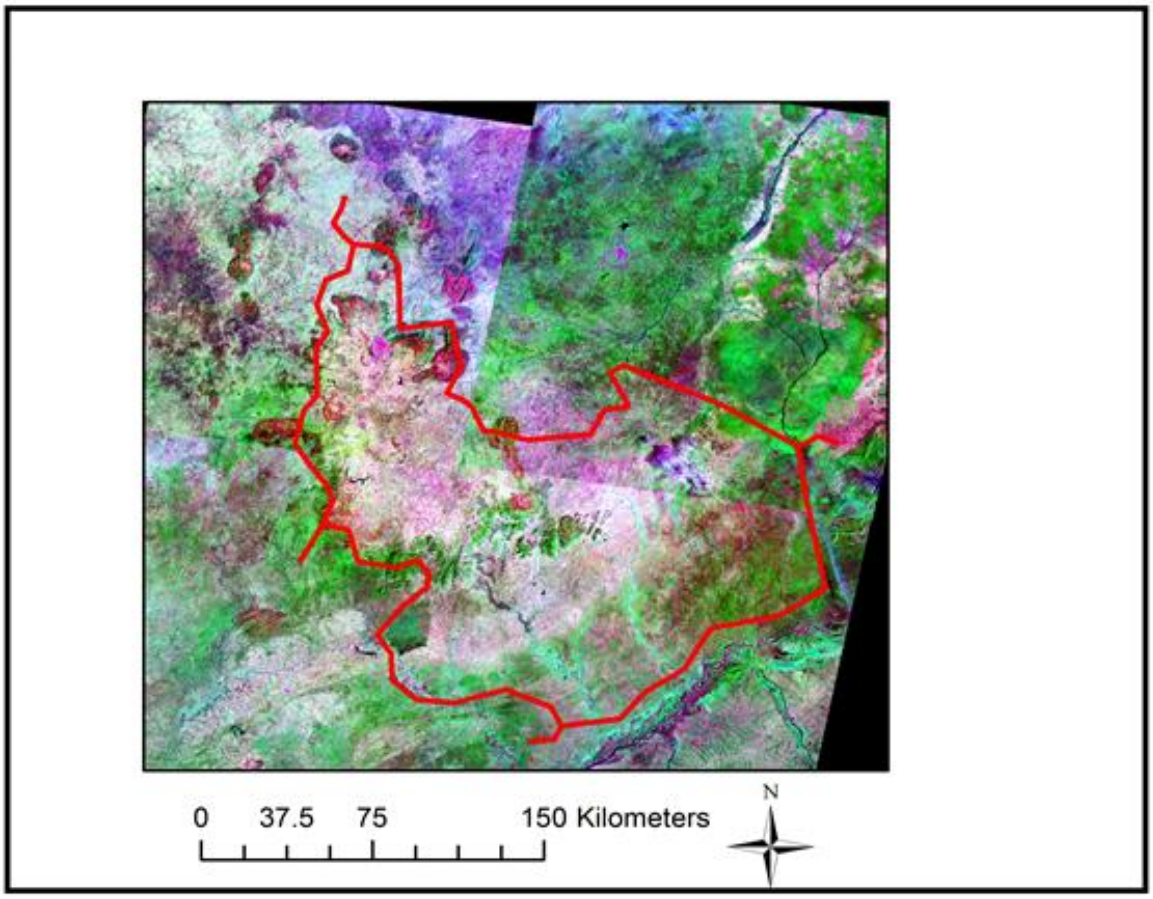

Figure 7: Mosaicked Map of four scenes and boundary line covering Plateau State.

4. Result and Discussion

The mosaicked map of the state reveals a unique geography where the entire plateau is surrounded by its boundary known to be the source of the state's name. There are also scattered bare rock formations around the north that looks captivating and scattered around the grasslands such as the Kahwang rock formation, a basalt rock around the Bachi district, a hillock called Wase Rock that is a striking dome down some distance away from the plateau in the south-eatern part with the shape of an inselberg, known to be a ranch for a specie of Ravens in Africa. There is the Kerang highlands, a volcanic hill that sources the SWAN natural mountain spring and the Shere hills with the highest peak where an abstract composite view of the Jos city capital of the state can be taken.
The plateau is the source of several rivers that flows to Bauchi, Kaduna, Hadejia, Yobe River and regions of narrow and deep valleys that traverses all the edges of the plateau. Volcanic activities of long time history must be resultant of the old and Younger granitic rocks that are predominant in the Plateau (Official website, 2016).

5. Conclusions

This study has shown that the Landsat-8 image data is ideal for the early exploration studies in arid and semi-arid regions where there are sparse vegetative coverage. There are certainly several additional band combinations that would be useful for visualizing Landsat 8 scenes.

In some situations, loading a grayscale image of a single band might also help to visualize specific features or phenomena. There are many analysis techniques that can be applied to multispectral imagery to extract specific features of interest. These algorithms rely on the same principles of reflectivity and absorption at various wavelengths that allow us to see certain features when visualizing them with different band combinations. An important point to note is that if a particular band, or combination of bands, does a good job of helping you visualize a feature that is of interest to you, then it is highly likely that this band, or combination of bands, can be used to help you isolate that feature from your image

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