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MONITORING DESERTIFICATION USING TASSEL CAP TRANSFORMATION INDEX IN YANAKARI NATIONAL PARK, BAUCHI STATE, NIGERI

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ABSTRACT

Desertification is a process that integrate climatic elements with human activities in transforming productive land into an ecological impoverished area generally refers to as desert. Nigeria is one of the countries in the sub-Sahara Africa that is faced with a rapid desert encroachment, with a notable effect on the northern part of the country where the Yankari Park is located. This research project investigated the greenness, brightness, and wetness maps of Yankari Park compiled from images taken for five epochs (2014 to 2018) in order to examine the rate of desertification in the Park. The three maps have shown that, in 2014, the study area has small patches of open spaces denoted by low greenness and wetness values but with high

Introduction:

The intimacy between drought and desertification phenomena in the environment has been a long-known phenomenon. They were described by Oladipo (1993) as a twin environmental hazard. Drought and desertification are global environmental problems affecting developed and developing countries in many regions of the world, where the required causal synergistic climatic variations and anthropogenic inputs thrive. They are accompanied by the reduction in the natural potential of the land, the

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brightness values. These areas were majorly located in the south-eastern part of the study area as well as in the far northern part of it. In 2015, a rapid change in the land cover was observed in all the maps with large portion of the study area, especially around the boundary, converted to open space or bare soil indicating desertification. However, a steady recovery of the grass land was observed from 2016 to 2018 making the area largely dominated by grass land. Although, the grass land did not only expand towards the open space areas but also towards the forested areas causing deforestation. Hence, the study area is not experiencing desertification at the moment but deforestation and it needs to be addressed to avoid carbon loss and to prevent the tendency of future desertification in the area.

Keywords: *Brightness, Wetness, Greenness, TCT, GIS, Remote Sensing, Landsat TM.*

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depletion of surface and groundwater have negative repercussions on the living conditions and the economic development of the people are affected by it (Abahussain et al., 2002). Drought and desertification processes integrate climatic elements with human activities in transforming productive land, into an ecological impoverished area generally refers to as desert. Drought and desertification cause degradation of once a fertile land through long term changes in the soil, climate and biota, which results in desert-like conditions. Nigeria is one of the countries south of the Sahara faced with a rapid desert encroachment, with notable effects on the northern part of the country. Desertification phenomenon has been reported in the northern Nigeria since 1920s, but the impact has been more glaring since the famine of 1971 to 1973 in this part of the country. Desertification affects fifteen northernmost state of the country (Jaiyeoba, 2002) and almost one-fifth of the total Nigeria land area is becoming decertified. These states of the country are agricultural area supply most of the country's agricultural products such as cowpea, tomato, melon, pepper, onion, cow, ram and many more. Though the contribution of climatic variability to drought and desertification phenomena, but these are aggravated by the unsustainable activities of human in the environment. Such activities include deforestation for industrial purpose

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and fuel wood, urbanization, bush burning, agro-activities on marginal lands and other sustainable agricultural activities. Desert encroachment is moving southwards. The impact is intense because agro-economy of Nigeria is dependent on rainfall and hence affected by fluctuating weather. Nigeria signed the convention of the United Nation to Combat Desertification on 30 October 1994 but the desert encroachment assumed increasing proportion and it a threat to the nation's economy (Okoli and Ifeakor, 2014). Tercula (2015) reported that Nigeria loses about 350,000 ha of land every year to desertification and the impacts are manifested on the environment and general livelihood of Nigerians. Desertification causes loss of biological diversity, contribute to disease burden, alter geo-chemical composition of the soil, contribute to water scarcity, reduced agricultural yield hence, contribute to food insecurity, reduced economic growth among other unfavorable impacts. As emphasized by Medugu (2009), a lot of policies and programmed have been implemented by Nigerian government to combat desertification, yet the problem is rather aggravating because of the problem that has been treated as a sectoral issue instead of an integrated approach that will bridge the gap between the formation of policy and strategies of combating drought and desertification. Among such policies and programmed are Arid Zone Afforestation Project (AZAP) in 1977, the River Basin Development Authorities (RBDA) in 1987, Federal and State Environmental Protection Agency (FEPA / SEPA) and the Great Green Wall Project among others. This paper examines the causes and impacts of desertification in the Nigeria environment, with a view to proffer solutions that will bridge the gaps in the existing national efforts to combat the environmental problems of drought and desertification.

Statement of Problem

Desertification is a problem that is seriously threatening the Northern Nigeria. There are many states in Northern Nigeria that are in the frontline of this issue of desertification they include the following states: Sokoto, Kano, Adamawa, Kaduna, Niger, Zamfara, Yobe, Borno, Kebbi, Bauchi, and Jigawa. Odigor (2010) shows hat in a place like Bauchi State for instance, sand dunes are advancing each year. Take Note of the following facts giving by Odiogor (2010). The Northern part of Nigeria is endowed with a large expense of arable land that has over the years proves a vital resource for

agriculture and other economic activities. But the Sahara Desert is advancing south wards at the rate of 6.0 percent every year.
Consequently, Nigeria loses about 350,000 hectares of land every year to desert encroachment. This has led to demographic displacements in villages across 11 state North. It is estimated that Nigeria loses about $1.5 billion every year owing to rapid encroachment of drought and desert in most parts of the areas, this necessitated this study.

Objectives:

a. To evaluate the rate at which desertification has affected Yankari National Park between 2014 and 2019.
b. To examined various changes of desertification decline in the study area.
c. To suggest a possible measure to be applied to tackle desertification in the study area

Study area

Yankari National Park is a park located in the south-eastern part of Bauchi town in the Bauchi state of Nigeria. It was established as a game reserve in 1956 and became a national park in 1991. It covers 870 square miles (2,254 square km). The park, at an elevation of about 1,600 feet (500 m), has characteristic savanna vegetation, including swamps in river floodplains, grasslands, and thick bush. Yankari is rich in animal life, with antelopes (roan, waterbuck, bushbuck, and hartebeest), elephants, hippopotamuses, giraffes, baboons, hyenas, lions, leopards, and crocodiles. Special features of the park include ancient sandstone cisterns, carved by former inhabitants for water storage, and the Wikki Warm Springs (https://www.britannica.com/).
Yankari National Park is a large wildlife park located in the south-central part of Bauchi state, in northeastern Nigeria. It covers an area of about 2,244 square kilometers (866 sq mi) and is home to several natural warm water springs, as well as a wide variety of flora and fauna. Its location in the heartland of the West African savanna makes it a unique way for

tourists and holidaymakers to watch wildlife in its natural habitat. Yankari was originally created as a game reserve in 1956, but later designated Nigeria's biggest national park in 1991. It is the most popular destination for tourists in Nigeria and, as such, plays a crucial role in the development and promotion of tourism and ecotourism in Nigeria. It is also one of the most popular eco-destinations in West Africa.

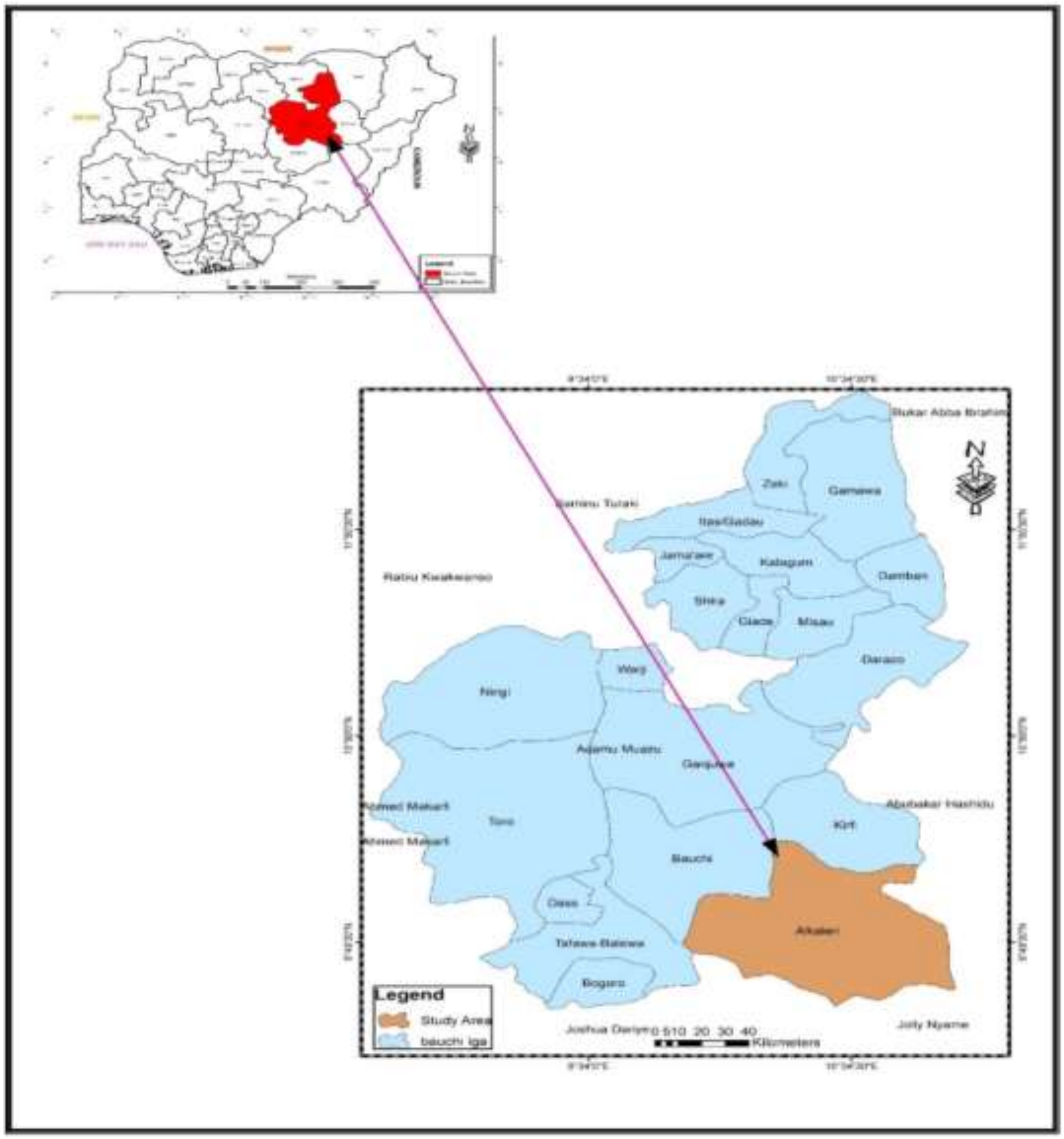
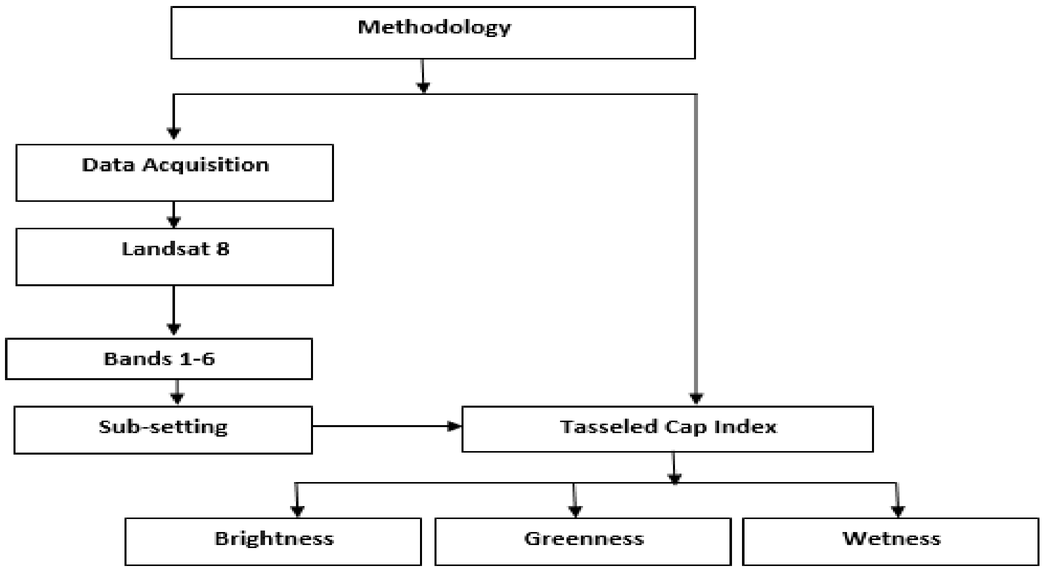


Figure 1: Locational Map of the study area **Yankari National Park** at Alkaleri L.G.A

Source: ArcGIS 10.6 G_N Tsundass Nig Ltd

METHODOLOGICAL FLOW CHAT.



Data Analysis

The data collected from Earth explorer was analysed using ArcGIS 10.6.1. This was done through the use of standard GIS functions tools and commands. The greenness, brightness, and wetness maps were compiled for the study period and investigated to understand the land cover changes in the area and to investigate the desertification status of the area within the study period.

Wetness is mostly connected with water contents. 'Wetness' is analyzed, shows that it contrasts the sum of the visible and NIR bands with the sum of the SWIR bands. The SWIR bands are considered to be the most sensitive to both soil moisture and plant moisture, so the contrast between these two sets of bands mainly highlights moisture-related scene characteristics. Greenness is associated with vegetation; Greenness is calculated by directly applying the reflectance factor-based transformation to an at-satellite reflectance image might not be able to differentiate dark green vegetation from bright soil. The at-satellite reflectance-based greenness image, however, is similar to the NDVI image and they both reveal the spatial pattern of green vegetation.

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Brightness is related to the soil and albedo, the at-satellite reflectance-based transformation generally does not have this problem when applied to clear and near cloud-free at-satellite reflectance images.

RESULT DISCUSSIONS

By following the methodology mentioned above, TCT coefficients are derived for different land cover types in different time periods to make the derived scenes representative of all sorts of important features. Table 2 shows the coefficients of the TCT components utilized. From table 2, it is evident that Brightness Correlation Coefficient for Landsat 8 at satellite reflectance has all positive loadings. It means that all six bands contribute for its overall value with bands 4 (Red), 5 (NIR) and 6 (SWIR1) as maximum contributors.

Table 1.0: TCT coefficient for Landsat 8 satellite Reflectance

TCT	*Band 2 (Blue)*	*Band 3 (Green)*	*Band 4 (Red)*	*Band 5 (NIR)*	*Band 6 (SWIR1)*	*Band 7 (SWIR2)*
Brightness	0.3029	0.2786	0.4733	0.5599	0.508	0.1872
Greenness	-0.2941	-0.243	-0.5424	0.7276	0.713	-0.1608
Wetness	0.1511	0.1973	0.3283	0.3407	-0.7117	-0.4559

Source: Source: ArcGIS 10.6 G_N Tsundass Nig Ltd

This research study analyzes the greenness, brightness, and wetness maps of the Yankari Park, compiled from the images taken for five epochs (2014 to 2018) in order to monitor and assess the desertification condition of the Yankari Park. The greenness, brightness, and wetness maps of the study area for the study periods are presented in figure 2 to figure 4 respectively.

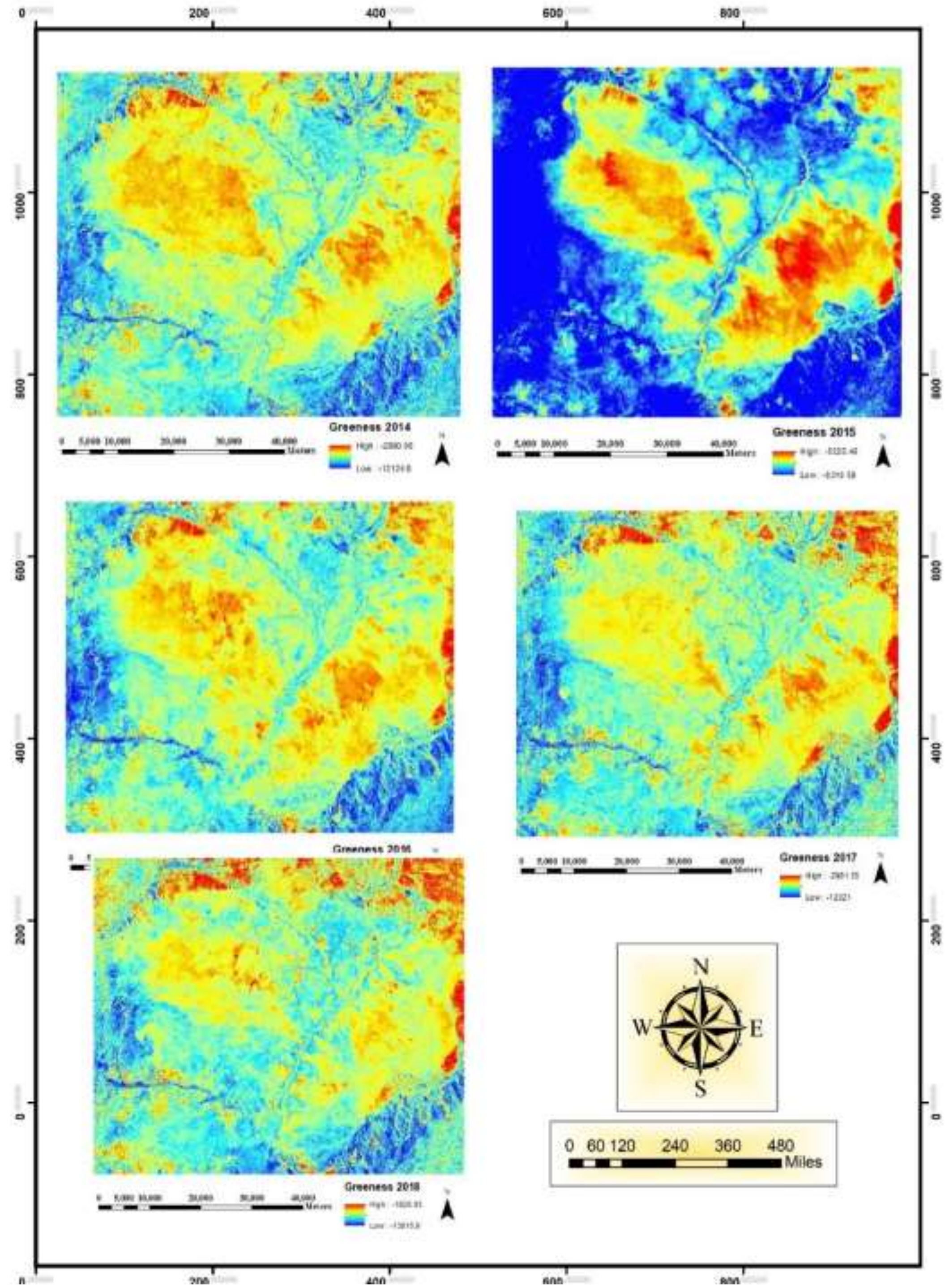

Figure 2. Greenness Map of the study area Yankari National Park.
Source: ArcGIS 10.6 G_N Tsundass Nig Ltd

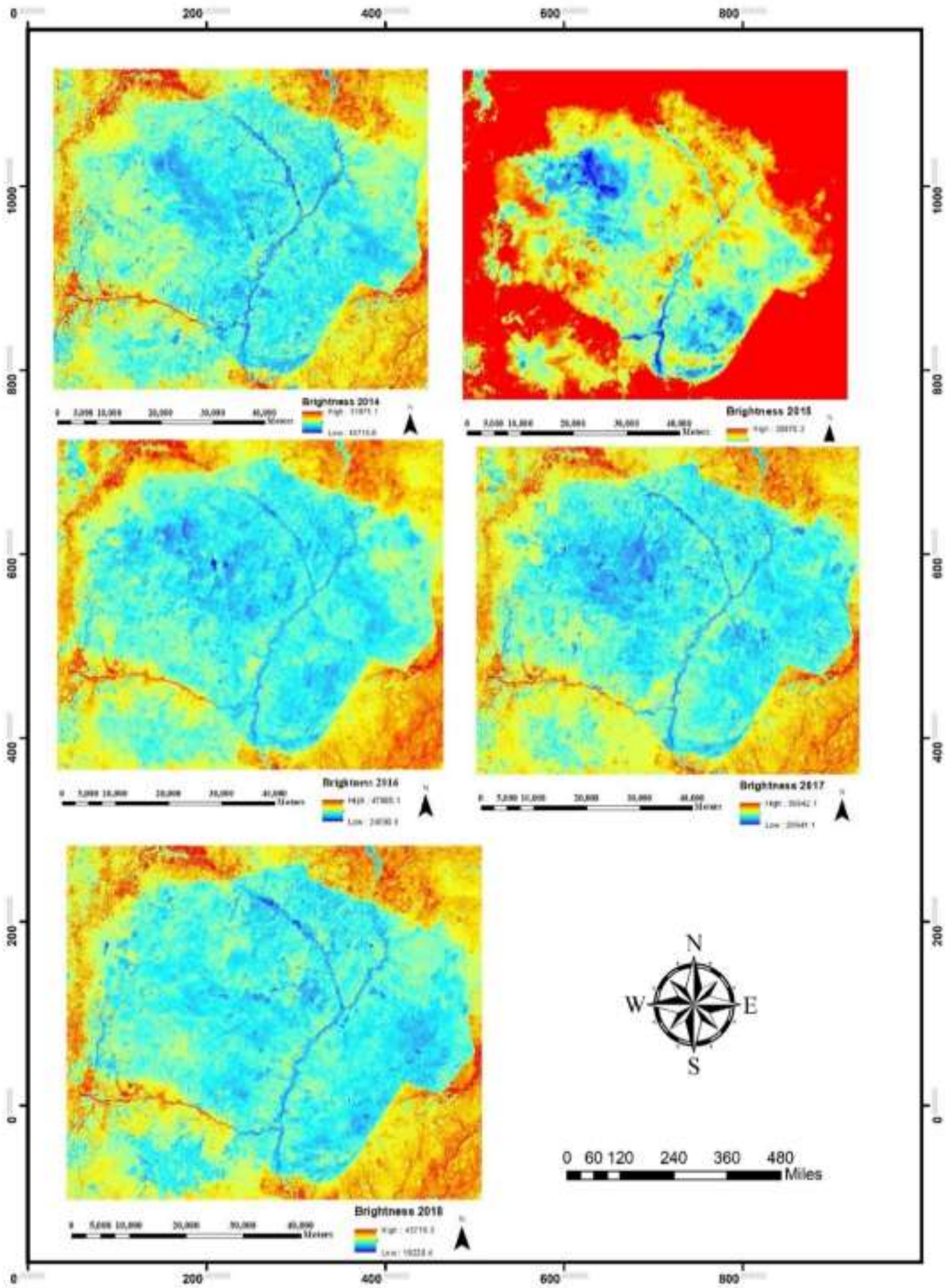

Figure 3: Brightness Map of the study area Yankari National Park.
Source: ArcGIS 10.6 G_N Tsundass Nig Ltd

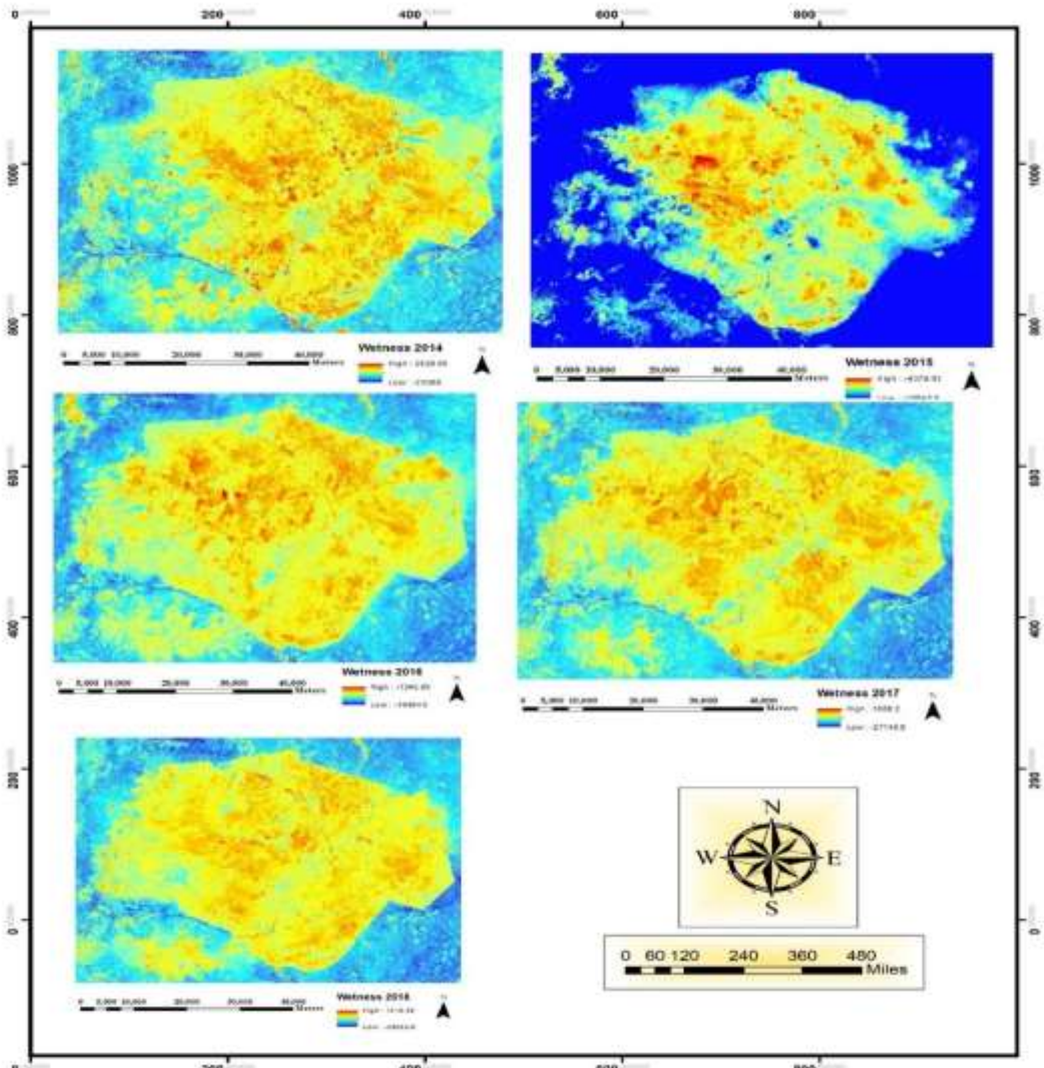

Figure 4: Wetness Map of the study area **Yankari National Park**.
Source: ArcGIS 10.6 G_N Tsundass Nig Ltd

The Greenness map in (fig, 2) shows that in 2014 there are only few patches of area with no vegetation (very low greenness) especially around the south-eastern part of the area as well as the eastern part of it. These areas appear to be open space, as classified by Aliyu and Ariff (2006). In this year, the peak/reserve has the dominance of high greenness pixies. This shows a dominance vegetated area or forested area.
In 2015, the greenness map appears to be dominated by very low greenness pixels (fig 2) with few pixels having moderate greenness value. These show that some of the grass land (moderate greenness pixels) in

2014 were converted to open space or bear soil (very low greenness value). This might as the result of the time difference of the acquisition of the images of the two periods or as the result of the desertification affecting the area. The very high greenness area in 2014 were retained in 2015. This shows that forested areas were not affected within this period.

In 2016, the greenness map of the area seems to have similar characteristics as that of 2014 (fig. 2). This shows a kind of re-growth of grasses initially converted to open space or bare soil between 2014 and 2015. However, some of the high greenness pixels/areas (forest) in 2015 were reduce or converted to moderate greenness areas (grass land) in 2016 making the grass land heavy a dominance in the park.

The trend of the grass land reclaiming its areas from open space maintained both in 2017 and 2018 (fig 3). This because, the moderate greenness pixel values (grass land) have taken over the low pixel areas (open space) in both 2017 and 2018. However, deforestation was observed between 2015 to 2018 (continue conversion of the high greenness area to low greenness areas).

As brightness is related to soil areas with high brightness depicts soil/open space areas while vegetation and water bodies show a relatively low brightness value. The brightness map of the study area (fig 3) has shown that in 2014, the south-eastern as well as the far northern part of the park are covered by bare soil/open space (high brightness value). This was similarly identified in greenness map of the particular year. However, some of the northern parts of the park were not captured as soil in the greenness map as seen in the brightness map. This shows that using brightness or greenness alone to interpret the land cover situation or status of an area is not enough, but the two can complement each other.

In 2015, the brightness map of the area has shown that the area is dominated by high brightness pixels around it boundaries with low and moderate brightness pixels around the centre, this indicate that soil. Open space is located around pixels (grass land) in 2014, converted to open space in 2015. This was also identified in the greenness map (fig. 2) of the area. Most of the high brightness pixels in 2015 were converted to low brightness pixels (fig. 3) in 2016 showing a conversion of open space/bare soil to grass land. This conversion has center diet the earlier believe of desertification in 2015.

The steady conversion of open space (high brightness pixels/areas) to grass land (moderate brightness/ areas) to grass land (moderate brightness pixels/areas) was observed between 2016 and 2018. This was similarly observed in the greenness map. This steady conversion clearly shows that vegetation is going more ground while bare soil/open space is reducing ground. In a broader view, certification is not happening in the area.

Wetness is mostly connected with water contents and is calculated using a mean infrared, visible and short-wave infrared band. These bands are very sensitive to both soil and plants moisture and can be used to study desertification or land cover change. The wetness maps for each of the years under study (fig. 4) clearly shows high similarities with both greenness and brightness map.

In a nutshell, high wetness and greenness (low brightness) are associated to vegetated areas in the study area while low wetness and greenness (high brightness) areas are associated to open space and or bare soil. Therefore, vegetation in the area has reduced between 2014 and 2015 (fig. 2 to 4) but steady increases from 2016 to 2019. The park is majorly dominated by low vegetating in all the study year, except in 2015. Also, low vegetation and open space are majorly located around the boundary of the study area. The forested area is in all the years including 2015 that has high dominance of open space. As such, deforestation occurred in the area but not desertification, therefore the study area is not under any threats of dessert enrolment.

Summary and conclusion

TCT compresses the data into few bands associated with physical scene characteristics of the land surface that can be used in classifying land cover and monitoring it changes. Brightness, Greenness and Wetness are some important components of TCT mostly used in assessing land cover changes, including desertification. Brightness is related to the soil and albedo, Greenness is associated with vegetation, and Wetness is mostly connected with water contents.

The brightness, greenness, and wetness maps of the study area have shown very similar results for all the study period, in term of meaning not appearance. Brightness has shown to be indirectly related to greenness and wetness, but all the components have shown no sign of desertification, especially between 2016 and 2019. However, a strange result was observed in 2015 which appears to be sign of desertification.

In general, there is small deforestation in the study area within the study period but not desertification. Also, grass land is steadily dominating the study area.
However, a transformation solely depends upon the interpretation of the data, standardization was necessary to develop uniformity in the TCT based on Landsat MSS, TM and ETM + sensors as well as those based on the new sensors. This study investigated the method using TCT coefficients to simulate OLI image to be used as a dummy target in PR method for transforming OLI orthogonal space. The resulted transformation coefficients successfully differentiated soil from vegetation, vegetation from water and bare soil features from water features. The standardized approach used in this study has a great potential for deriving coefficients for future sensors such as Sentinel-2, etc. Validation of coefficients will be done in a form of a comparison with ETM + in a detailed next study.

Recommendations

1. The use of image differencing or any of the techniques of supervised or unsupervised classification can be used for more reliable results.
2. The use of change detection technique can give a precise amount of change in land cover between two periods as well as the land cover from which a particular one changes to or from. Therefore, is recommended for future studies.
3. The management of the Park should continue utilizing the approaches they are using in expanding the grass land but should be restricted to the open space and bare soil areas and avoid the forested areas in order to prevent deforestation and to minimize carbon lost in the area.
4. A predictive model should be produced for future occurrence of desertification
5. Public awareness on the consequences of desertification should be initiated

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