INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 5)
Available online at: www.ijariit.com

Detecting tree cover loss in Damaturu town using multi-temporal landsat imagery

Modibbo Babagana-Kyari
modibbobgk@gmail.com
Yobe State University, Yobe State, Nigeria

Yusuf Maina-Bukar
mainayusuf2@yahoo.com
Yobe State University, Yobe State, Nigeria

ABSTRACT

Damaturu, the administrative headquarters of Yobe State, Nigeria, has been experiencing a rapid developmental change in its physical landscape due to the monumental impact of urbanization in the last two to three decades, and this development has been occurring progressively at the detriment of the urban trees. No attempt has been made singularly to investigate the extent of this negative development as it keeps on progressing at an alarming rate. Thus, this study aimed at detecting and mapping the changes occurred in the last three decades, so as to the find out the extent of the change. For this purpose, Landsat Thematic Mapper (TM) of 1986, and Landsat Eight/8 (OLI) scene of 2016 was acquired and used. Normalized Difference Vegetation Index (NDVI) and change detection technique of image differencing was employed to detect the changes. The threshold parameter of 45% and 48% were used respectively for the increased (gain) and decreased (loss) option to obtain the image differencing (Highlight change map) result in ERDAS Imagine software version 15. Findings revealed that there are a significant tree cover canopies gain and loss amounting to an area cover of 2,193.75 and 1150.38 Hectares of land respectively. People's quest of land for shelter, administrative status of the town, as well as lack of strong environmental bye-laws were identified as the main drivers of the observed changes. Overall, the study provides the valuable information required for sustainable urban development. This study also demonstrates the usefulness of medium resolution Landsat imageries and change detection techniques in observing environmental changes at a local level.

Keywords— *GIS, Image Differencing, Land cover, Multispectral, NDVI, Satellite Imageries.*

1. INTRODUCTION

Urbanization and uncontrolled rapid urban expansion have been tremendously affecting urban tree cover and their spatial density as well, in most developing countries of the world (Fuwape, & Onyekwelu, 2011). Urban trees cover as defined in many pieces of literature, refers to the structural layers of leaves, branches, and stems of trees that cover the surface of the earth when observed from above (Konijnendijk., Ricard, Kenny & Randrup, 2006; Sexton et al., 2013). Generally, urban vegetative cover, particularly urban trees, offers various benefits that can improve the quality of an environment in and around urban centers. These benefits include provision of cleaner air and water resources (Westphal, 2003), regulation of surface and atmospheric urban heat (Nowak & Dwyer, 2007; Rogan et al., 2013; Cowet, 2014), reduction of ultraviolet solar radiation, and absorption of automobiles noises (Nowak & Dwyer, 2007), and these benefits collectively provides healthy human living in cities (Bowler, Buyung-Ali, Knight and Pullin, 2010). Because of this benefits, periodic mapping and assessment of urban tree cover are of interest. Vegetation has far-reaching impact in an urban environment as it provides hydrological, ecological, social and climatic benefits (Munyati & Mboweni, 2013). Vegetation cover most especially trees are largely viewed as an essential indicator component of land cover (Naibbi, Baily, Healey, & Collier, 2014). Studies throughout developing country have repeatedly reported that most urban communities are losing tree cover and other vegetal land use due to wide ranges of anthropogenic activities such as urbanization (Roy, 2006; Macaulay, 2014). Therefore, Spatio-temporal analysis of tree cover using GIS and remote sensing techniques greatly helps in understanding land cover dynamics (Keles, Sivrikaya, and Cakir, 2007; Cakir, Sivrikaya, & Keles, 2008), and an information regarding vegetation cover (trees) could significantly serve as a reliable information to overcome the problem of land cover challenges (Zhang et al., 2008).

Conversely, such information is not readily available in most developing countries and Nigeria is not in an exception. In Nigeria, information regarding land cover, especially vegetation cover is seriously lacking and where they do exist they are not up-to-date (Naibbi et al., 2014). For example, Ademiluyi, Okude and Akanni (2008) reported that there had been a little research in the area of land use/cover in Nigeria, most especially periodic monitoring of vegetation covers across many localities. Similarly, Northern Nigeria and the North-eastern region, in particular, happens to be a hotspot of land cover change as stressed for example by Macaulay (2014), due to fragile nature of the ecological zone plus induced human practices such as rapid urbanization. Vegetation cover such as urban trees is often cleared locally and globally by direct human activities such as urbanization. As reported by many studies, barely can we find any vegetation cover that has not been affected by human activities across the world (Hegazy & Kaloop, 2015). It has been reported, for example by (Daramola & Ibem, 2010), and Sands (2013) that urban centres and towns are growing at detriment of trees, and clearing of trees are pre-requisite for towns and cities expansion, due to provision of more infrastructural development necessary to cater for the needs of growing population.

Damaturu, the selected study region is not in any way going contrary to this challenges of land cover change as the town has expanded more than three times of what it used to be since it became the administrative headquarters of the state on 27th August 1991 as it was carved out from the old Borno State. Jajere, Musa and Ismail (2015) had earlier reported that with the twenty-three years of the creation of Yobe State, Damaturu town has witnessed a massive growth in its socio-economic activities joined with enormous infrastructural development to carter the need of the growing population. This development has substantially affected the virgin land cover of the town as many trees were cleared to build more, roads, government housing estates and other private residential structures within and around the Town.

However, little effort has been made in previous studies, especially at a local level to singularly map and detect the extent of this development as the trees are continuously being lost. Although, in relation to the chosen study area, some studies had attempted to study the general vegetation loss across the entire State (Naibbi et al., 2014). Contrariwise, their research was concentrated mainly in the southern part of Yobe State comprising Potiskum, Nangere and Fika localities as their chosen case study for the investigation. Several related studies conducted in some Nigerian Urban centres (Ifatimehin, 2006a; Oluseyi, 2006; Braimoh, & Onishi, 2007; Ifatimehin, 2008b; Innocent, 2013; Owoeye and Ibitoye, 2016) have found that rapid urbanization has largely affected trees in their respective study areas. Therefore, there is a need for an up-to-date information regarding the land cover change, virtually in all Nigerian towns and cities, as they experience rapid urbanization. Ramadan, Feng, and Cheng, (2004), and (Owoeye & Ibitoye, 2016) highlighted that periodic mapping and assessment of any land cover types is very crucial for environmental management and development planning.

Multispectral Landsat imagery can detect vegetation cover as low as 10% in a given study area (Tole, 2002); many researchers have recommended that remote sensing is a powerful tool for vegetation change detection study at a local as well as regional level (Kumar, 2011; Sexton et al., 2013;). The use of remote sensing indices such as Normalized Difference Vegetation Index (NDVI) and Image Differencing has been in used in vegetation change detection and monitoring over regional and local study areas (Herrmann, Anyamba & Tucker, 2005; Munyati & Mboweni, 2013; Naibbi et al., 2014). Normalized Difference Vegetation Indices is useful in determining the presence, absence, and condition of vegetation from multispectral Landsat imagery (Alphan & Derse, 2013). In this study, Normalised Difference Vegetation Index (NDVI) and change detection technique of image differencing has been applied to Landsat imageries to assess tree covers loss in the study area. The study is aimed at detecting and mapping the areas of tree cover gain and loss in the study area. The outcome of this study would provide valuable information required for sustainable urban management and future environmental planning.

2. MATERIALS AND METHODS

2.1 The Study Area

The study centers on Damaturu Town and its immediate surrounding (figure 1) land. Damaturu is an administrative headquarters of Yobe State, which was carved out from former Borno State on 27th, August 1991. Relatively, it lies within the northeast geopolitical region of Nigeria. It lies geographically on Latitude 11° 44' 48" N, and Longitude 011° 57' 57". The study area is a nodal settlement connected with various federal highway road infrastructures. It has a total land area of about 2,366 km^2. It has a total population of 46,000 peoples according to the 2005 census (National Population Commission, 2016). The predominant socio-economic activities found in the study area are agriculture, civil services, banking, and commerce. The composition of the dwellers of the Town is government workers, businessmen, and peasant farmers. The vast lands of the study area are used for the building of shelters, grazing of livestock, and peasant farming.

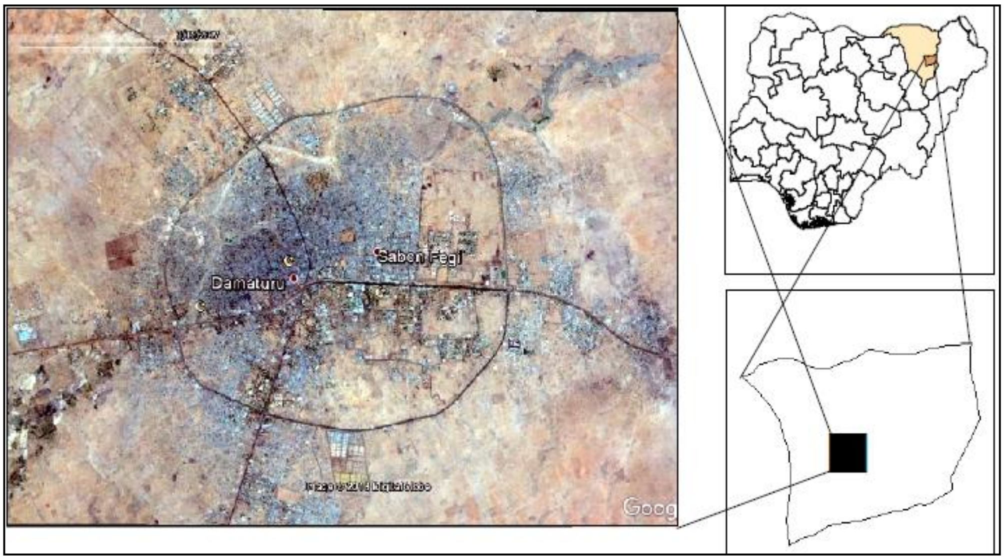

Fig. 1: Location of the study area in Nigeria

Source: Extracted from Digital globe (2018)

2.2 Climate and vegetation

The study area lies mostly within the Sahel-Savannah ecological zone of Nigeria. The climate of the area is tropical with three distinctive seasons; rainy seasons, dry and hot seasons respectively. The rainy seasons set in April and terminate in September, while the hot-dry seasons last for the rest of the months with an average temperature of 37ºC (Garba & Brewer, 2013). The predominant tree species found in the area are Acacia, Dum palm, Tamarind, and Baobab trees. Shrubs are available all year round while grasses mostly disappear with the termination of rainy seasons due to excessive grazing and fuelwood sourcing carried out by the study area locals; and regenerate at the onset of the wet seasons which mostly comes in around April (Musa, 2012; Naibbi et al., 2014).

2.3 Datasets and Techniques

For this study, two multispectral Landsat imageries of two different epochs were used to cover three decades. These imageries were freely sourced in 2018 from the official websites of the United State Geological Survey (Earthexplorer.usgs.gov). The detailed characteristics of the imageries are presented in table 1.

Table 1: Characteristics of the imageries used

Sensor type	Acquired data	Path	Row	Pixel resolution
Landsat TM	07-Feb-1986	186	52	30
Landsat 8/OLI	07-Feb-2016	186	52	30

Accordingly, the study area map, the road Shapefile that was overlaid on the classified map, were obtained from the DIVA-GIS official website (http://www.diva-gis.org/gdata). The image tile used in (figure 1) to depict the study area was sourced from digital Globe via Google earth engine. The detailed methodology employed to achieve the purpose of the study is presented below (figure 2).

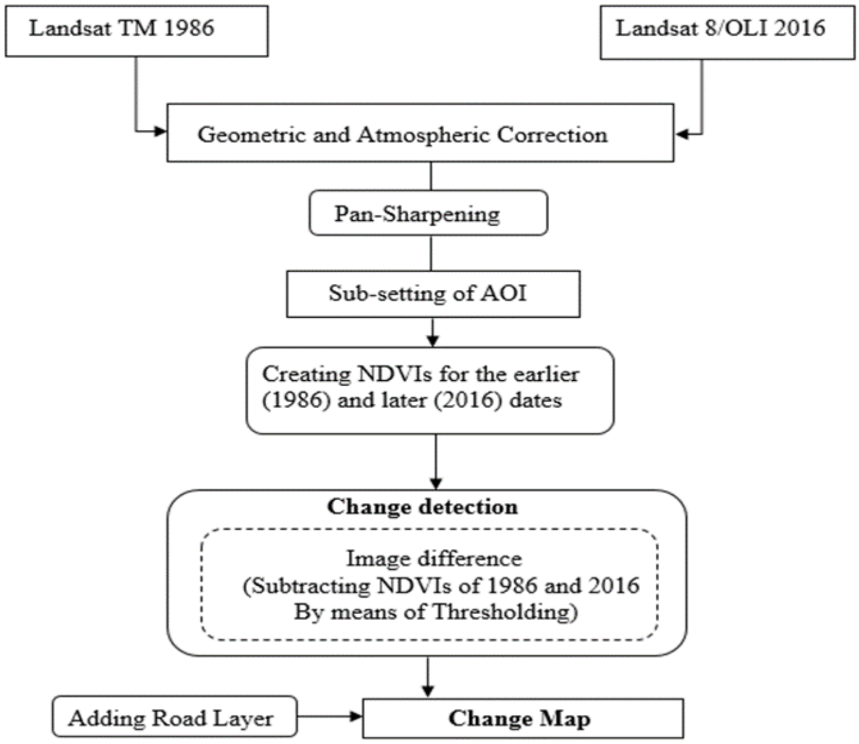

Fig. 2: The methodology flow chart

2.3.1 Image Pre-processing

The two acquired Landsat scene of the study area were geo-registered to UTM WGS84 projection. After this, the correction of the acquired multispectral imageries was carried out to enhance the quality of the imageries and remove the adverse effects of atmospheric condition interference. After the area of interest (AO) was cropped from the two acquired imageries, the panchromatic band of the Enhanced Thematic Mapper (ETM+7) (Band 8) of the area was used to pan-sharpened the imageries to a 15m resolution from 30m resolution respectively (figure 2). This was carried out using the spatial modeler tools of ERDAS imagine software version 15. This was done because some of the trees and shrubs of the study area are very difficult to detect as accurately as it should in the original 30m pixel resolution. Behnia (2005) reviewed the importance of pan-sharpening in digital image classification, and he recommends that it enhances image quality.

2.3.2 Normalised Difference Vegetation Index (NDVI) and Change Detection

The Landsat data of two different epochs were used for the analysis as presented in (Table 2.1). These two high-quality cloud-free image scenes were acquired for the period of dry seasons so as to reduce the negative interference of seasonal and perennial herbs which could lead to an incorrect result. The NDVI images were derived from the two Landsat data acquired (1986 and 2016 imageries) by using the multispectral bands. ERDAS Imagine Software Version 15 was used to process the imageries. This has been derived using the following formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Whereas NDVI stands for Normalized Difference Vegetation Index and NIR represent Near Infrared in band 3 and RED refers to Red light in band 4 respectively. Using this formula, the two NDVI images for 1986, and 2016 were generated in ERDAS imagine software using Band 3 and 4 of the Landsat 5; and band 4, 5 combinations in Landsat 8/OLI as the red and Near-Infrared bands respectively. This is because the study aimed to detect tree cover canopy in the study area by using the two classified NDVI images using the change detection techniques of Image differencing. Therefore, only the above mentioned spectral bands have been used to derive required maps for the analysis. As vegetation absorb sunlight in the photosynthetically active radiation (PAR) spectral portion of the electromagnetic spectrum (EMS), which they use as a source of energy in photosynthetic activity, while they reflect energy in near-infrared (NIR) wavelengths. Hence, vigor green vegetative cover appears relatively dark in the visible section and relatively bright in the near-infrared wavelengths. NDVI is variously used to study vegetation cover and easily detect areas of significant changes (Bellone, Boccardo & Perez, 2009). A similar approach has been used by (Ramadan, Feng & Cheng, 2004) to assess the presence, and condition of vegetation in land cover change assessment in Shaoxing city of China, and also (Bakr, Weindorf, Bahnassy, Marei & El-Badawi, 2010) in a similar study conducted in Egypt. Similarly, Munyati and Mboweni (2013) applied the use of NDVI to assess land cover change in the semi-arid area of South Africa and better results were obtained.

2.3.3 Change Detection and techniques

In this study, change detection techniques of image differencing were used to detect the areas of significant tree cover loss and gain in the study region. The two classified NDVI images of 1986 and 2016 (as before and after images of the study area) were equally subtracted to obtain the results of the image difference using the ERDAS Imagine Software Version 15. This change detection technique basically worked upon by comparing the NDVI images on a pixel basis. With this method, each pixel from an image (Earlier Image) is subtracted from its corresponding pixel in another image (later Image) based on its brightness value. The change areas were extracted from the difference images and labeled as highlight change map through the means of a thresholding procedure in the software. Mas (1989), and Al-Rawashdeh (2011) Indicated that Cautious attention should be paid in selecting the befitting threshold value to improve change detection result by an analyst. Threshold parameter value of 45% and 48% were used for the increase and decrease parameter option, and the residual image of highlight change was finally chosen for the analysis. To calculate the areas of tree cover canopy change from the classified image, an ERDAS IMAGE software version 15 was also used to quantify the change areas in hectares. The resulting NDVI and difference image result was then visually assessed to evaluate the changes occurred for the selected study period. Sigh (1989) reviewed the change detection method based on image differencing as it worked well in mapping the coastal zone of Texas despite some associated shortcomings. Change detection techniques of image differencing are the most useful method of extracting land cover change between two different periods, especially vegetation change (Lu, Mausel, Brondízio & Moran, 2013), and it is the most widely applied technique (Afify, 2011).

3. RESULTS AND DISCUSSION

This Section presents, describe and simultaneously discuss the study findings. As it could be seen, figure 3 present the earlier (1986) and later (2016) NDVIs images as classified from the imageries acquired for the study. Normalised Difference Vegetation Index (NDVI) is a powerful technique which is normally used to show the presence, the condition of the vegetation of an area. The NDVI ratio ranges in value between −1 as negative and +1 as a positive value; and generally high or positive NDVI values indicate greater vegetation or vigour vegetation, while low NDVI corresponds to stressed vegetation or represent areas partly void of vegetation (figure 3).

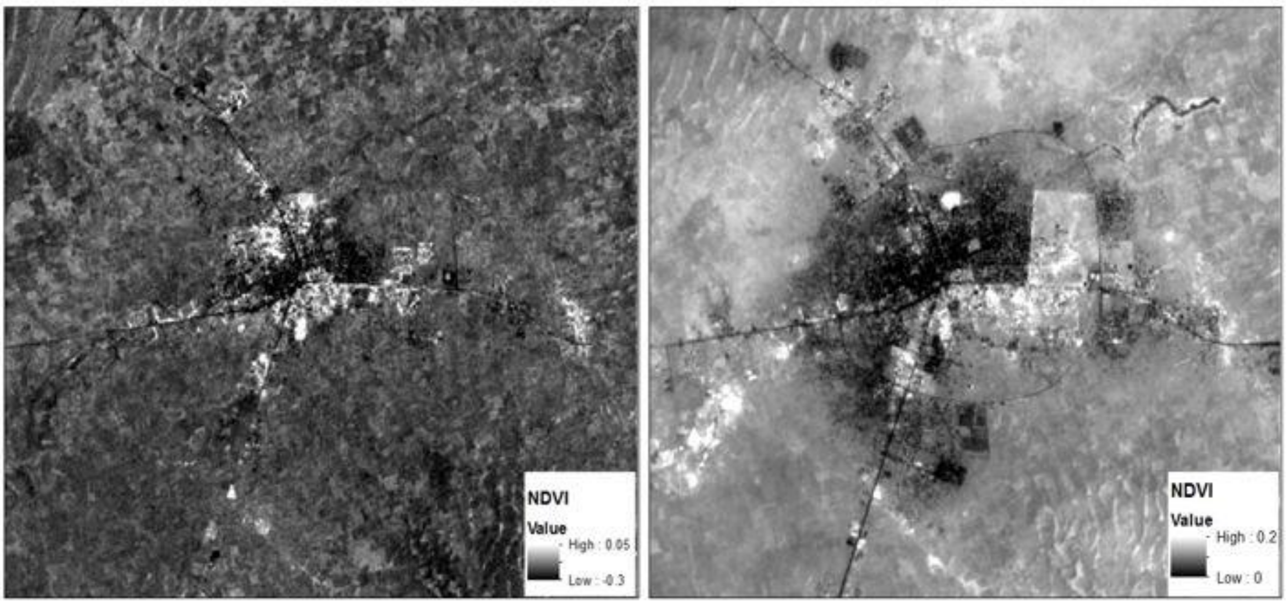

Fig. 3: The earlier (1986) and later (2016) NDVI maps of the study region showing the tree covers

Similarly, extremely low NDVI value getting to zero in the maps represent areas that are void of tree covers, for example, bare land, water bodies and built-up areas as shown in black (figure 3). For the purpose of this study, and based on the personal knowledge of the study area, the brightness shown on the NDVI maps (figure 3) represent tree covers of the study area, particularly Neem trees

(Azadirachta Indica) as they appeared to be the predominant tree species found within and around the town. Based on the results presented in this section it could be said that Damaturu Town has experienced significant changes in its tree covers in the last three decades of the Town's Growth. It could be seen vividly from figure 3 that the tree canopies which are represented in a brighter colour (High NDVI) had suffered a persistent decline in both density and spatial distribution across the study area. It could be observed from the earlier image (1986) figure 3 that there were partly dense trees in the North-western axis (areas covering places like Nayi-Nawa, Ajari, Pawari Njiwaji lay-out, and Abasha wards) and the South-western axis (covering the areas of State Low-cost housing estate, forestry quarters and their surrounding areas).

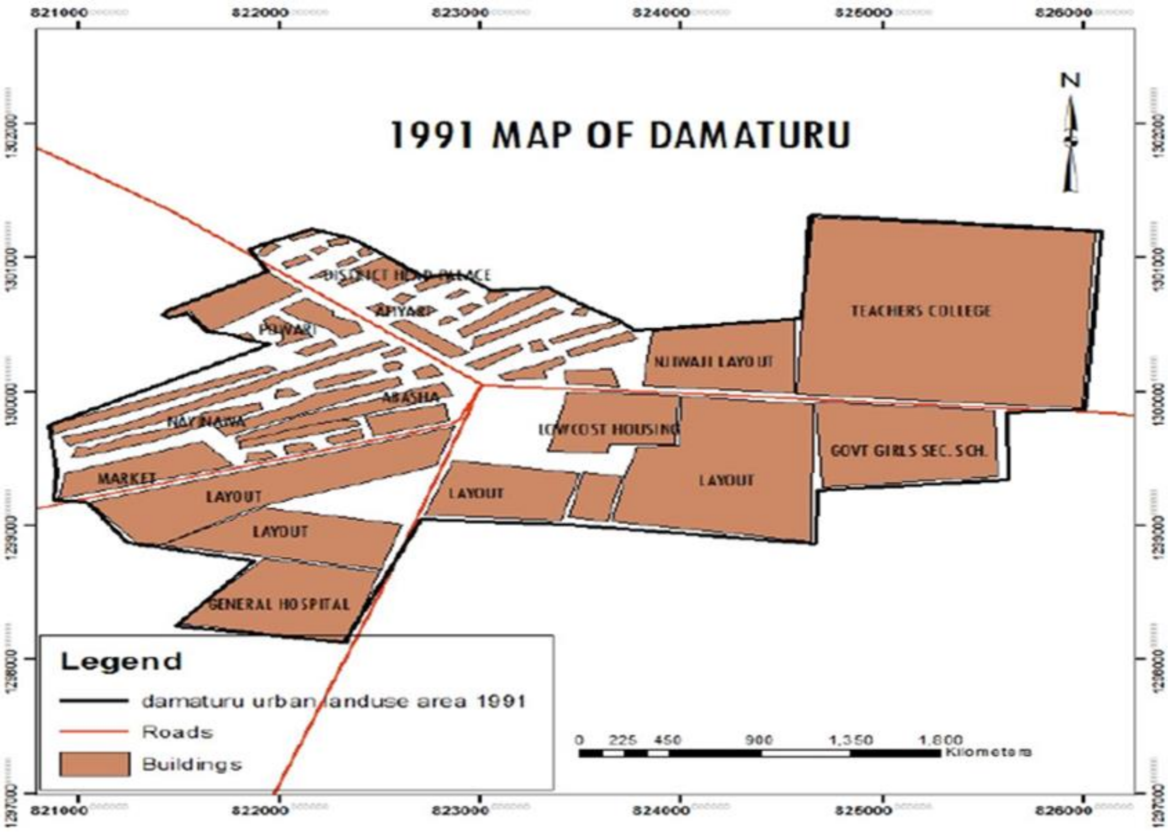

Fig. 4: The 1991 land use map of Damaturu Town

Source: Adapted from (Jajere et al, 2015).

During that time, particularly (around 1987) lush communities of Neem Trees (Azadirachta Indica) predominantly occupied the areas. These trees are believed to have been mostly planted by the government of Borno State originally through its massive afforestation programs which were introduced for the state during the 1980s, (see, for example, Naibbi et al., 2014). This is because, since the aftermath of 1970-1980s drought which affected the entire Northern Nigeria region, an effort has been made by the government (in the then Borno State) towards tackling the environmental challenges of drought and desertification. Government Policy in the name of Arid Zone Afforestation Project (AZAP) was purposely put-in-place to encourage massive trees plantation in every nook and cranny of not only the study area (Damaturu) but the entire state at large. It was under this program, an exotic drought-resistant tree species known as ''Azadirachta Indica'' were introduced (figure 5).

Fig. 5: Neem tree plantation (Azadirachta Indica)

Source: Adapted from (Naibbi et al, 2014)

With the introduction and distribution of this tree species across the study locale, now it becomes the dominant trees which occupy virtually every public and private lands in the study area (Odihi, 2003). As the town changed in rank from a mere local government to the new state headquarter, these important tree covers also began to suffer a decline in both density and spatial distribution due to the massive expansion of the town as a result of urbanization (figure 3). This loss could best be attributed to the impact of urbanization directly resulting from the increased provision of infrastructural development as the status of the town changes. In the course of the provision of infrastructures, many trees have been cleared without due regards; as no, any strong state environmental bye-laws exists to control the unsustainable development of the land, except the then Borno State government decree enacted in 1987 by the Military regime. This point has been reported in the work of (Naibbi, et al., 2014) as it significantly affected the overall vegetation of the State. This negative development, if it is not urgently arrested, could positively alter the micro-climate of the town as observed, and this is a very staid threat with the 21st-century climate change challenge.

Conversely, figure 6 portrays the tree cover change map of the study area. The areas appeared in green color represent the areas of tree cover gains, while the red represents areas of a massive tree covers reduction or loss and the black denotes the background or the unchanged areas (figure 6). This single map shows the significant changes that had occurred to the study area tree covers throughout the selected study periods (1986-2016). It should be observed that the North-Western section of the Town appeared to have suffered a massive decline (Figure 6) nearly losing about 1150.38 Ha of lush tree covers. It can be said that this massive loss has originally resulted from the uncontrolled and unsustainable development of the area as most of the plots in the area are very cheap and hence the low- income earners predominantly occupy and develop the area at the detriment of the trees. This finding befittingly corroborates with what (Daramola and Ibem, 2010), and Sands (2013) pointed-out that urban centers and towns are growing at the detriment of trees. It should be seen in the 2016 NDVI image (figure 3) that the built-up areas indicated in dark color have massively sprawled out radially engulfing the surrounding land unlike in the later image (1986) figure 3.

The more significant part of these areas largely falls under the main traditional settlement of the city, an area which had started experiencing the impact of the town's expansion. Initially, it was this part of the town that first received an influx of migrants and developments when the status of the city (Damaturu) has shifted to administrative headquarters of the state in 1991.

Similar studies conducted by Jajere et al. (2014), and (Sidi & Yerima, 2018) found out that, most of the built-up areas spread out from the axis of the town with massive expansion witnessed during 1995-2005 selected period. Therefore, it was this factor that massively degraded the tree covers of the area as shown in figure 6. The construction of infrastructural facilities such as the township tarred access roads, inner-ring roads, drainages, and schools, as well as the expansion of the existing ones by the state government, had spectacularly contributed in the loss of tree covers of the Town.

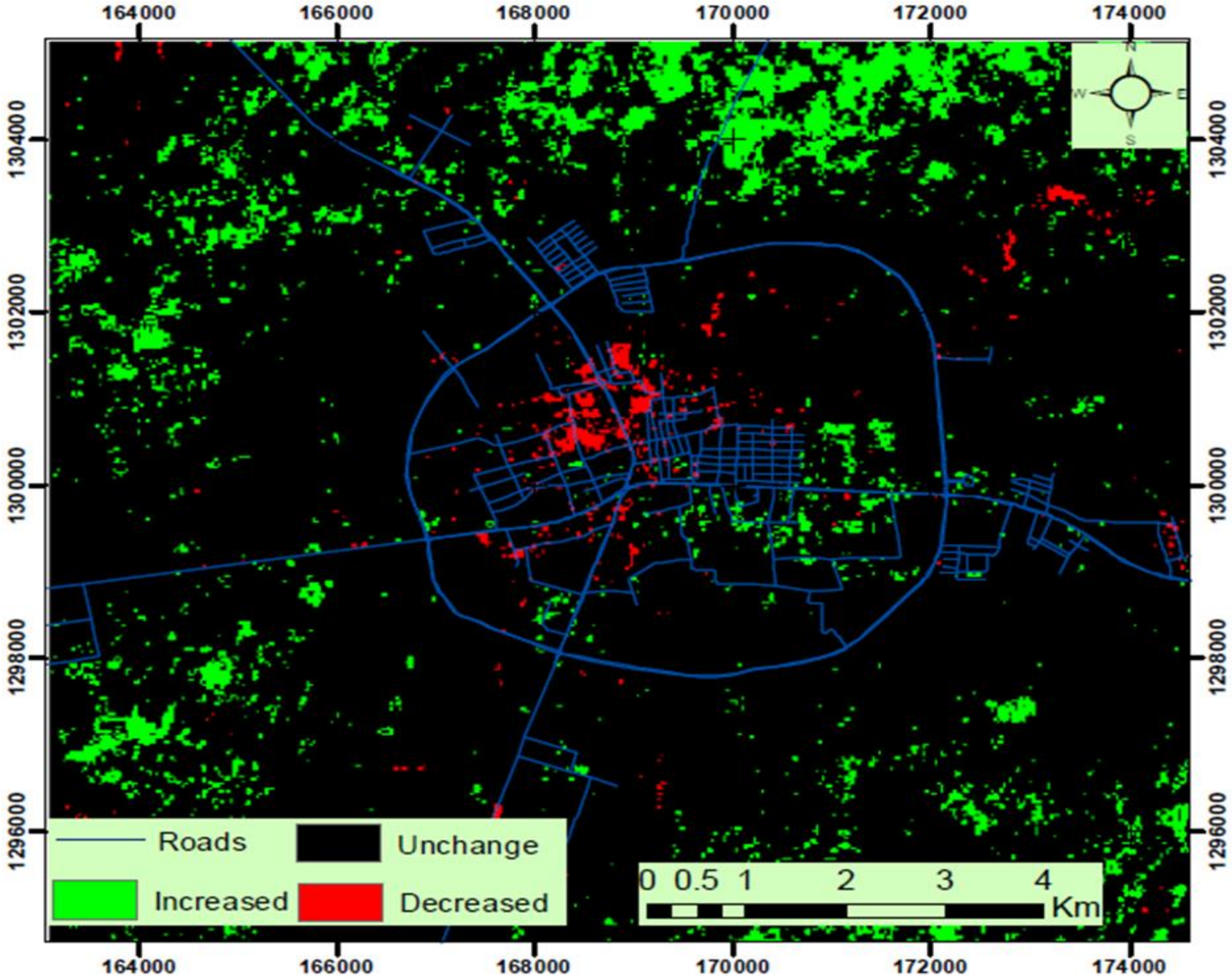

Fig. 6: The Image difference map highlighting the change areas of tree cover (gain and loss) for the selected study period (1986-2016)

Figure 6 depicts a relative tree cover gain amounting to a total land area of 2,193.75 Hectares when put together with that of the surrounding lands. Notably, it could be seen that there is partly tree cover gain at the eastern section of the town, and this gain could simply be attributed to the land use status of the area. This is because, all the critical Government buildings (Structures) such as government house, Stadium, State Secretariat complex, federal polytechnic, and government girl's colleges all fall under this area as observed from the field and the 1991 land use map (Figure 4).

It could be said that it is this particular reasons that conserved the existing tree communities of the area because the areas were classified by the authority as Government Reserved Area (G.R.A) hence it remained undisturbed. If not because of this factor the remaining of the trees would have been cleared and replaced with paved structures such as roads and houses. Furthermore, the tree cover/vegetation gain seen from the surrounding areas of the town is largely that of the perennial herbaceous plants and other scattered different trees species. Therefore, a persistent decline of tree communities has been recognized based on the above findings, and this is a very negative development confronting the entire study area if it continues unchecked. Consequently, this could possibly lead to urban heat Island (UHI) phenomena, as it could potentially alter the micro-climate of the town and its surroundings.

4. CONCLUSION AND RECOMMENDATION

The above findings show that Damaturu town has been losing it tree covers due to the effect of rapid expansion and growth of the town. With the three decades of the town's growth and expansion (1986-2016), there has been a serious degradation of tree covers particularly, Neem tree as they predominantly occupied the study area landscape. The principal aim of this study was to detect the areas of the significant tree covers gain and loss of the study area using the freely available medium resolution multispectral Landsat imageries, and change detection techniques. The Damaturu town was chosen as the study area because it has been experiencing rapid urban development ever since when it became the state headquarters of the State (Yobe) in 1991. Much of the studies conducted regarding the development of the town were overly focused on the general land use/cover mapping and assessment (see, for example, Jajere et al. 2015; Sidi & Yerima, 2018). None of the studies focused specifically on the loss of tree covers within and around the town as it continuously appeared to have suffered much degradation among all the land cover types of the area, and hence the current study attempted to focus on this area. The study found that between1986-2016, the town has lost tree cover area of about 1150 Hectares due to the massive expansion witnessed by the town. People's quest of land for shelter, administrative status of the town as well as lack of strong environmental bye-laws were viewed and identified as the main drivers of the negative changes observed among others.

Based on the study outcomes, the following recommendations are made: concerned authorities should enact strong environmental bye-laws that can encourage urban tree conservation and discourage clearing of trees; the State Ministry of environment, Ministry of land and housing and other stakeholders should collaborate in order to address the causative drivers of the change; the Government should also review the existing urban land development planning policy of the entire state (Yobe) so as to include the Strategic Environmental Assessment (SEA). It is upon through this, sustainable urban land development can be achieved, and the trees can be protected.

Critical reflection

The use of medium Landsat imagery to detect and map tree cover canopy loss proved to be the biggest limitation of the study. This is because, there are some tree species that are too small, and therefore their canopy cannot be detected as it should with the 30m resolution of the Landsat imagery. High-resolution satellite imagery such as Rapids-Eye Imagery and the IKONOS could have yielded a better result, and these are not freely available. Secondly, interference of perennial herbaceous vegetation also partly affected the NDVI classification, and the image differencing output as well, even though both the two imagery were acquired in the dry season periods. Moreover, the used of two imageries to assess the changes occurred for the last three decades was also another limitation of the study. Because information regarding what has happened between the 30 years' time span is not known. Nevertheless, the study has produced good result despite the above shortcomings as it provides first-hand information required by the concerned authorities. Future study should seek to improve the above-mentioned limitations.

5. REFERENCES

[1] Abdalla, J. D. (1994). *The evaluation of Satellite imagery in a geographic information system (GIS) for monitoring land cover changes in the semiarid area of north-eastern Nigeria* (Unpublished doctoral dissertation). Cranfield University, United Kingdom.

[2] Afify, H.A. (2011). Evaluation of change detection techniques for monitoring land-cover changes: A case study in new Burg El-Arab area. *Alexandria Engineering Journal, 50,* (2), 187-195

[3] Al-doski, J., Mansor, S. B., & Shafri, H. Z. M. (2013). NDVI Differencing and Post classification to Detect Vegetation Changes in Halabja City, Iraq. *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG), 1*(2), 01-10.

[4] Al Rawashdeh, S. B. (2011). Evaluation of the differencing pixel-by-pixel change detection method in mapping irrigated areas in dry zones. *International Journal of Remote Sensing, 32*(8), 2173–2184. 10.1080/01431161003674634

[5] Bakr, N., Weindorf, D. C., Bahnassy, M. H., Marei, S. M., & El-Badawi, M. M. (2010). Monitoring land cover changes in a newly reclaimed area of Egypt using multi-temporal Landsat data. *Applied Geography*, *30* (4), 592–605. 63

[6] Bellone, T., Boccardo, P., & Perez, F. (2009). Investigation of vegetation dynamics using long-term normalized difference vegetation index time-series. *American Journal of Environmental Sciences, 5* (4), 460–466.

[7] Behnia, P. (2005). Comparison of four methods for data fusion of ETM+ multispectral and pan images. *Geospatial Information Science*, *8*(2), 98–103.

[8] Bowler, D.E., Buyung-Ali L., Knight, T.M., & Pullin, A.S. (2010). Urban Greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and urban planning. 97(3), 147-155.

[9] Daramola, A & Ibem E.O. (2010). Urban Environmental Problems in Nigeria: Implications for Sustainable Development. *Journal of Sustainable Development in Africa. 12,* (1). 124-145

[10] Fuwape, J.A. and Onyekwelu, J.C., (2011). Urban Forest Development in West Africa: Benefits and Challenges. *Journal of Biodiversity and Ecological Sciences*, 1(1) 77 – 94.
[11] Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment*, *80*(1), 185–201.
[12] Gregorio, A.; Jansen, L. J. M. (2000). Land Covers Classification System. Food and Agriculture Organization (FAO) of the UN. Rome: 179.
[13] Hegazy, I. R., & Kaloop, M. R. (2015). Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. *International Journal of Sustainable Built Environment*, *4*(1), 117-124.
[14] Herrmann, S. M., Anyamba, A., & Tucker, C. J. (2005). Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. *Global Environmental Change*, *15*(4), 394–404
[15] Homer, C., Huang, C., Yang, L., Wylie, B., & Coan, M. (2004). Development of a 2001 national land-cover database for the United States. *Photogrammetric Engineering & Remote Sensing*, *70*(7), 829–840.
[16] Keles, S.; Sivrikaya, F.; Cakir, G. (2007). Temporal changes in forest landscape patterns in Artvin forest planning unit, Turkey, *Environmental Monitoring and Assessment 129* (1–3) 483–490.
[17] Ifatimehin, O. O. (2006b). An Analysis of Urban Expansion and Loss of Vegetation Cover in Lokoja, Using GIS Techniques. *The Zaria Geographers*, *17*(1).
[18] Jajere, A. A., Isma'il, M., & Musa, I. J. (2014). Analysis of Future Urban Growth Scenario of Damaturu Town in Yobe State, Nigeria. *Global Journal of Research and Review*, *1*(3), 117-124.
[19] Jajere A.A., Ismail, M., & Musa I, J. (2015). Analysis of land use land cover change in Damaturu. *Science Domain international. 3,* (1)7-19.
[20] Kumar, D. (2011). Monitoring Forest cover change using remote sensing and GIS: A Global Perspective. *Research Journal of Environmental Sciences*. 5 (2). 105-123.
[21] Konijnendijk. C., Ricard, R., M. Kenny, A., and Randrup, T. B. (2006). Defining urban forestry, a comparative perspective of North America and Europe. *Urban Forestry and Urban Greening*, 4: 93-103.
[22] Lawan, A. I. (1996). *The application high spatial resolution satellite data for land use and land cover mapping and inventory in northeast Nigeria* (Unpublished doctoral dissertation). Cranfield University, United Kingdom.
[23] Lu, D., Li, G., Moran, E., & Hetrick, S. (2013). Spatiotemporal analysis of land-use and land-cover change in the Brazilian Amazon. *International Journal of Remote Sensing*, *34*(16), 5953–5978. 10.1080/01431161.2013.802825
[24] Lu, D., Mausel, P., Brondízio, E., & Moran, E. (2004b). Change detection techniques. *International Journal of Remote Sensing*, *25*(12), 2365–2401. 10.1080/0143116031000139863.
[25] Mas, J.-F. (1999). monitoring land-cover changes: A comparison of change detection techniques. *International Journal of Remote Sensing*, *20*(1), 139–152.
[26] Musa, J. (2012). An Assessment of the Effects of Desertification in Yobe State, Nigeria. *Confluence Journal of Environmental Studies*, *7* (4) 234-341
[27] Munyati, C. & Mboweni, G. (2013). Variation in NDVI values with a change in spatial resolution for semi-arid savanna vegetation: A case study in north-western South Africa. *International Journal of Remote Sensing*, *34*(7), 2253–2267.
[28] Naibbi, A. I., Baily, B., Healey, R. G., & Collier, P. (2014). Changing vegetation patterns in Yobe state Nigeria: An analysis of the rates of change, potential causes and the implications for sustainable resource management. *International Journal of Geosciences*, *05*(01), 50–62.
[29] Nowak, D.J. and Dwyer, J.F. (2007). Understanding the Benefits and Costs of Urban Forest Ecosystems. In J. E. Kuser (Ed.), Urban and Community Forestry in the Northeast (2nd ed.,). Springer Netherlands, pp. 25–46
[30] Olsson, L., Eklundh, L., & Ardö, J. (2005). A recent greening of the Sahel—trends, patterns and potential causes. *Journal of Arid Environments*, *63*(3), 556–566.
[31] Odihi, J. (2003). Deforestation in afforestation priority zone in Sudano-Sahelian Nigeria. *Applied Geography*, *23*(4), 227-259.
[32] Ramadan, E., Feng, X., & Cheng, Z. (2004). Satellite remote sensing for urban growth assessment in Shaoxing city, Zhejiang province. *Journal of Zhejiang University Science*, *5*(9), 1095–1101.
[33] Tole, L. (2002). An Estimation of Forest Cover and Change in Jamaica Using Landsat MSS Data. *International Journal of Remote Sensing, 23* (1) 91-106
[34] Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, *10*(6), 989–1003.
[35] Rogan, J., Ziemer, M., Martin, D., Ratick, S., Cuba, N., DeLauer, V. (2013). The impact of tree cover loss on land surface temperature: a case study of central Massachusetts using Landsat Thematic Mapper thermal data. *Applied Geography*. 45, 49–57.
[36] Sexton, J. O., Song, X. P., Feng, M., Noojipady, P., Anand, A., Huang, C., and Townshend, J. R. (2013). Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS vegetation continuous fields with lidar-based estimates of error. *International Journal of Digital Earth*, *6*(5), 427-448.
[37] Westphal, L. M. (2003). Social aspects of urban forestry: Urban greening and social benefits: A study of empowerment outcomes. *Journal of Arboriculture 29 (3): 137-147*
[38] Sidi., Y.D & Yerima., U. (2018). Assessing land use land cover Using GIS and Remote Sensing Approach in Damaturu, Yobe State. *Journal of Global Ecology and Environment. 8*(1), 34-42.
[39] Zhang, Y., Chen, Z., Zhu, B., Luo, X., Guan, Y., Guo, S., & Nie, Y. (2008). Land desertification monitoring and assessment in Yulin of Northwest China using remote sensing and geographic information systems (GIS). *Environmental monitoring and assessment*, *147*(1-3), 327-337.
[40] Sands, R. (Ed.). (2013). *Forestry in a global context*. CABI.ds

