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LAND COVER CHANGES IN DANBATTA LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

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Abstract
This research analyzed desertification and land degradation in Dambatta Local Government Area (LGA) of Kano State with the view to delineating hotspot areas that require intervention. The imageries used for the research analysis were obtained from National Space Research and Development Agency (NASRDA), Abuja. The data sets were captured by Landsat Multispectral Scanner/Thematic Mapper (MSS/TM) 1997, Landsat Enhanced Thematic Mapper Plus (ETM+) 2007 and Operational Land Imager (OLI) 2017. Maximum Likelihood Classifier (MLC) algorithm was used for classification. Post classification change detection technique was conducted using ILWIS 5.2 and later converted to shape files where it was imported to ArcMap 10.2 GIS software. The result of the classification was presented in tables, which were subsequently compared using Post Classification Comparison (PCC) technique to estimate and compute temporal and spatial changes as well as rate and area extent of changes between the four images. The result shows that desert encroachment has occurred in the study area at the rate of 5.65km^2/yr over the 20 years. A composite Land Cover map and NDVI map of 2017 were created and superimposed with the localities within Dambatta LGA, where the settlements requiring intervention were then drawn out. It revealed that almost all parts of the LGA require intervention. . However, some areas have more serious land degrdation issues than others. This has resulted from anthropogenic activities, environmental factors and erosion with negative effects on farmers, rural development, forest reserves and policy makers. Hence intervention in the form of afforestation is recommended to prevent further expansion of bare lands in the area.
Keywords: Landcover, Remote Sensing, GIS, Desertification, Land Degradation, Intervention, Kano State

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CHANGEMENTS DE LA COUVERTURE TERRESTRE DANS LA ZONE D'ADMINISTRATION LOCALE DE DANBATTA DE L'ÉTAT DE KANO, NIGÉRIA

Cette recherche a analysé la désertification et la dégradation des terres dans la zone d'administration locale de Dambatta (LGA) de l'État de Kano en vue de délimiter les zones de hotspot qui nécessitent une intervention. Les images utilisées pour l'analyse de la recherche ont été obtenues auprès de l'Agence nationale de recherche et de développement spatial (NASRDA), Abuja. Les ensembles de données ont été capturés par Landsat Multispectral Scanner/Thematic Mapper (MSS/TM) 1997, Landsat Enhanced Thematic Mapper Plus (ETM+) 2007 et Operational Land Imager (OLI) 2017. L'algorithme MLC (Maximum Likelihood Classifier) a été utilisé pour la classification. La technique de détection des modifications post-classification a été réalisée à l'aide d'ILWIS 5.2 et convertie ultérieurement en fichiers de forme où elle a été importée dans le logiciel SIG ArcMap 10.2. Le résultat de la classification a été présenté dans des tableaux, qui ont ensuite été comparés à l'aide de la technique de comparaison post-classification (PCC) pour estimer et calculer les changements temporels et spatiaux ainsi que le taux et l'étendue des changements entre les quatre images. Le résultat montre que l'empiètement du désert s'est produit dans la zone d'étude au rythme de 5,65 ^{km2} / an au cours des 20 années. Une carte composite de la couverture terrestre et une carte NDVI de 2017 ont été créées et superposées aux localités de la LGA de Dambatta, où les colonies nécessitant une intervention ont ensuite été dessinées. Il a révélé que presque toutes les parties de la LGA nécessitent une intervention. Cependant, certaines régions ont des problèmes de dégrdation des terres plus graves que d'autres. Cela résulte des activités anthropiques, des facteurs environnementaux et de l'érosion qui ont des effets négatifs sur les agriculteurs, le développement rural, les réserves forestières et les décideurs. Par conséquent, une intervention sous forme de boisement est recommandée pour empêcher une nouvelle expansion des terres nues dans la région.
Mots-clés: Couverture terrestre, Télédétection, SIG, Désertification, Dégradation des terres, Intervention, État de Kano

INTRODUCTION

Land Degradation has been a recognized environmental problem for decades. Its environmental effects have attracted global attention with the Sahel droughts and attendant food crises of the 1970s. It is a reduction in the lands actual or potential uses/a diminution or complete loss of the productive potential of the soil for current and/or future use. It is the decline in soil quality caused through misuse by humans and results in deterioration of soils life support processes and decline in its capacity to produce food, feed, fiber and fuel. The lost value may be related to the productivity of the land for agriculture, the environment as host to naturally-occurring species of flora and fauna or the environment as a place for other human activities such as mining and secondary industries, human habitation and waste assimilation. It has negative connotations that imply the loss of something of value within the environmental-economic system (UNEP, 1984; Abel and Stocking, 1987; Blaikie and Brookfield, 1987; Lal and Okigbo, 1990; Hellden, 1991; UNEP, 1992; Gretton and Salma, 1996; Gretton and Salma, 1997; Bisaro *etal*, 2011; UN, 2015).

Desert encroachment is one of the most serious environmental and socio-economic problems facing the world today, and indeed, Nigeria. The "expansion of the desert" theory culminated in the assertion by Lampery (1975) that the Sahara was expanding at a rate of 5.5m/year. Olagunju (2015) highlighted anthropogenic activities as the major causes of desertification and also summarized the anthropogenic activities influencing desertification in northern Nigeria. Nneji (2013) has attributed rapid economic growth and urbanization as causal factors of desertification.

Desert encroachment in the form of sand cover, leads to land and ecological degradation and eventually to environmental destruction. This situation is most noticeable within the arid, semi-arid and sub-humid zones of the worldVegetation has undergone changes especially in the forest regions, Sudan and Sahelian environment as a result of human activities Most areas of the Sudan and Sahel's agricultural farmlands are used as built-up areas or any other land use (Kessler and Stroosnijder, 2006).

Over the years, it has been observed that desertification is provoked by several factors including deforestation, erosion and wind. At the instance of heavy winds, the fine clays and silts are carried away as dust and the sand drifts into the dunes. This effect could be irreversible except through carefully planned rehabilitation programme (Gadzama, 1995). Irrigated cropping can also turn land into desert if not properly designed and managed as a result of water logging, salinization or alkalization. This scenario is already a reality on a number of irrigation projects in Nigeria today, such as the Bakolori irrigation, South Chad irrigation and the Hadejia-Jamaare Irrigation projects (Gadzama, 1995).

Therefore, the destruction of the environment via desert encroachment has assumed increasing proportions and is posing serious threats to food security, employment and other related nation's economy. Land is

increasingly becoming under pressure from anthropogenic activities, thereby leading to desertification and land degradation (Campbell, 2002; Burt, Boardman, Foster and Howden, 2016; Mentaschi, Vousdoukas, Pekel, Voukouvalas, and Feyen,2018; Keogh and Törnqvist, 2019). Productivity impacts of land degradation are due to a decline in land quality on site where degradation has occurred. Desert encroachment is one of the major causes of land degradation for agricultural purposes. Nigeria's agricultural production is without doubt vulnerable to many adverse effects of desertification.

The role of Kano State in the Nigerian economy cannot be overemphasized. With commerce and agriculture being the major contributors to Nigeria's economy from the state, land degradation is no doubt a threat to the effective operation of commerce and agriculture in Kano State. The study area (Dambatta Local Government Area) constitutes one of the largest Local Government Areas in the state and contributes in no small measure to the economy of Kano State in particular and Nigeria at large.

MATERIALS AND METHODS

Dambatta Local Government Area is located in the Northern fringe of Kano State. It lies approximately between Latitude 12° 25′ 59″ N and 12° 30′ 00″ N of the Equator and Longitude 8° 30′ 00″ E and 8° 50′ 00″ E of the Greenwich Meridian (Fig.1). Dambatta Local Government Area has a total land area of 732 km^2 accounting for approximately 3.6% of the total land area of 20,131 km^2 in the state (Mohammed, 2014). Generally, the study area lies within the "wet and dry" climate with more dry months than wet months (Olofin, 1987). Dambatta LGA falls within the tropical climate with well-defined wet and dry seasons, according to the Koppen's classification scheme. It has a low mean annual rainfall of about 880mm, with relatively hot and humid weather and a temperature of 27°C to 34°C. In drought years, mean annual rainfall could be lower than 450mm as in the case of 1972/73 drought (Abdulhamid, 2000). The rainy season last for up to four months (June to September) with its peak in the month of July and August. The dry season on the other hand begins in October and ends in April. The study area falls within the Chad formation underlain by sedimentary rocks of criterion origin. The relative relief here falls within the average of about 15 to 20 meters (Kano State Bureau of Land and Survey, 2001). The soil normally consists mostly of unconsolidated sediments which are predominantly sandy, silt to sandy loam (Kano State Bureau of Land and Survey 2001). About 75% of the land in the area is put to agriculture through rain-fed cultivation. The system of farming practiced by the farmers is mostly mixed cropping; few farmers practice mono-cropping (Kano Agricultural Development Project, 2001).

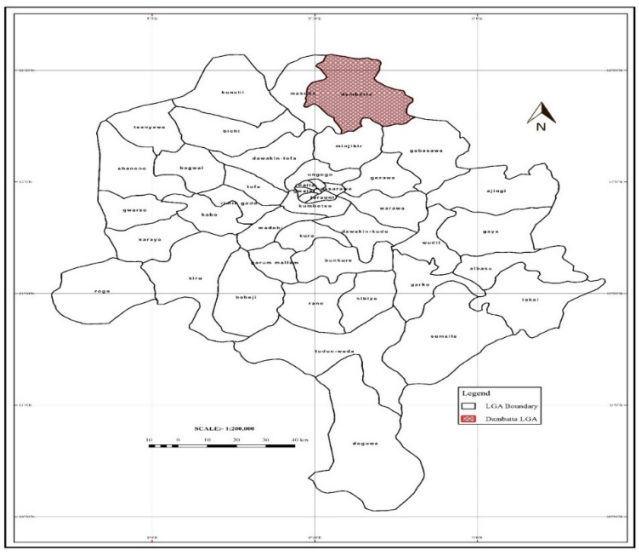

Fig.1: Kano State showing Dambatta LGA
Source: Niramart Technologies, 2017

The data used for this study includes three historical Landsat images covering the study area for the period of 20 years (1997-2017). The images of 1997, 2007 and 2017 with spatial resolution of 30m were obtained from National Space Research and Development Agency (NASRDA), Abuja. These data sets were captured by Landsat MSS/TM (Multispectral Scanner/Thematic Mapper) on 21th December 1997, while the other Landsat ETM+ (Enhanced Thematic Mapper Plus) was captured on 4th January 2007. The OLI (Operational Land Imager) Landsat of 2017 was captured on 24th of January 2017. A Landsat track is 185km wide. The Landsat image scenes was selected because of reduced spectral reparability and phonological stability as was noted by Ayuba (2006), that for any meaningful change detection, summer and winter are the best seasons because of their phonological stability. Also, selecting the summer or the driest period of the year enhances spectral reparability.

The administrative map of Kano State was used to extract the administrative boundary of Dambatta LGA. The base map of the study area was used to extract roads and drainage pattern of the study area for appropriate guide during reconnaissance survey and ground truthing. The GPS was used to acquire sampling points. While the three Landsat satellite imageries used for this study were acquired from NASRDA.

For the purpose of this study, reconnaissance survey was conducted so as to get acquainted with the area of study. During the reconnaissance survey, observation was made on the land cover/land use, vegetation cover, vegetation degradation, soil degradation, bare land and built-up areas of the study. It was observed that the area has both healthy and stressed vegetation which necessitated the generation of NDVI of the area. Soil degradation in the form of erosions and sand domes were also identified in the northern part of the study area. It was also observed that there were lots of lands formerly used for cultivation that were left bare because of infertility. These field observations assisted in carrying out supervised analysis of the study area.

Ground-truthing exercise was conducted to gather field data useful for the classification of the selected satellite image at Dambatta LGA. GPS points were used for training sample set for the classification. Some of the GPS point served as training sample set which was subsequently used for the classification of the most recent image of 2017. These same points were used for the classification of the previous image.

Supervised classification procedure was used in analysis of data, False color composites were developed for the individual images using three out of the respective bands and used to classify the three (3) clipped images separately for 1997, 2007 and 2017. Afterwards, maximum likelihood classifier (MLC) was used. Maximum likelihood classifier (MLC) is the most efficient and effective classification method for this study because it uses a probability density function which enables it to accurately classify land cover categories where residual ambiguity exists between overlapping classes in the measurement space. Thus, MLC was applied in ILWIS Academy software which assumed that image data were normally distributed and thus, pixels would have composed of a single land use type. The tables of the classification results were subsequently compared in post classification comparison (PCC) in order to estimate and compute temporal and spatial changes as well as rate and area extent of changes between the four images.

The data processing and manipulation was conducted using 'post classification change detection technique in Integrated Land and Water Information System ILWIS 5.2, and later converted to shape files where it was imported to Arc Map 10.2 GIS software. Landsat image of 30metres resolution covering the study area in 1997, 2007, and 2017 was used for land cover classification to identify the spatio-temporal changes in land cover (LC) of Dambatta LGA between 1997 and 2017. Normalized Difference Vegetation Index was used to establish the rate and spatial extent of desertification in the study area.

RESULTS AND DISCUSSION

A supervised classification using maximum likelihood algorithm was used for the three remotely sensed images and the results of the classification with other supportive data and ground truthing provides an overview of the major Land Cover (LC) features of Dambatta LGA between 1997 and 2017. However, five LC classes were identified on the classified digital maps. They are developed areas, agricultural land, vegetation cover, bare lands, and water bodies (Table 1). The ground trothing exercise and satellite imageries of 1997, 2007, and 2017 were used identify the land cover classes. The maps of the classified images were achieved and illustrated by Figure 2. A standard color code was used to represent the five (5) LC classes.

The green color represents vegetation cover, light green represents agricultural land, the brown color represents developed area, milk color represent bare land and blue represents water body.

Table1: Summary of the LC classes identified within the study area.

S/N	CLASS	DEFINITION
1	DEVELOPED AREAS	Densely populated built-up areas, cities and towns including both smaller urban centres, large scale nucleated settlements and villages with social amenities.
2	AGRICULTURAL LAND	Small scale subsistence farming usually of house hold or arable crops, to commercial farm lands.
3	VEGETATION COVER	Natural plants in general or the mass of plants growing in a particular place.
4	BARE LAND	Exposed bare sand surface with little or no vegetation cover.
5	WATER BODY	Natural and man-made stagnant water body usually created by damming streams.

Source**:** Author's field work (2018)

Environmental Changes and Land Degradation in Dambatta LGA from 1997 to 2017

The result of spatial variation and distribution of land cover categories within the spatio-temporal frame from 1997 to 2017 is presented in Figure 2.

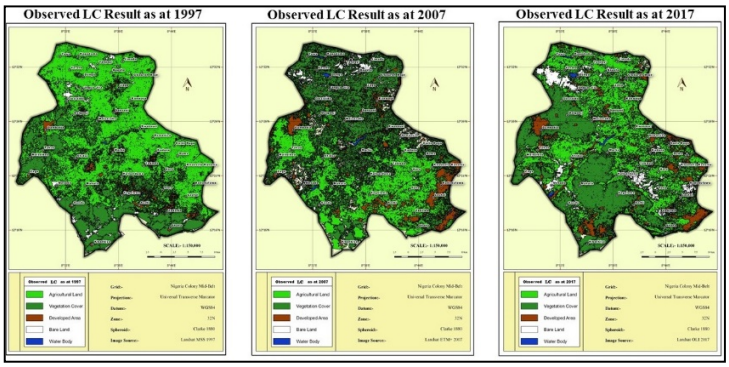

Figure 2: Land cover changes in Dambatta LGA between 1997 and 2017
Source: Author's field work (2018)

As at 1997, the level of anthropogenic disturbance in Dambatta LGA was minimal, and land degradation was very low with abundant agricultural farmlands in virtually all corners of the LGA and also vegetation cover as shown by the statistical distribution of LC (Figure 3). The agricultural land as at 1997 covered an estimate of about 51.7% of the total land area which is the highest spatial coverage, followed by vegetation cover at about 27.5%, developed area covered about 13.5%, bare land at 5.7%; while water body took 1.3% of the total land area.

It was also observed that within a period of 10years from 1997 to 2007 in Dambatta LGA, agricultural land had decreased significantly by over 50% while vegetal cover decreased by 10%. Developed areas and bare land had increased by 147% and 140% respectively (Figure 4). This depicts that over this period of time, agricultural land and vegetal cover are giving way for built-up areas and bare lands. While built-up areas are obviously resulting from anthropogenic activities, bare land could have resulted from anthropogenic activities or environmental factors (drought, less rainfall, wind and temperature).

Figure 5 shows a graphical presentation of the spatial distribution of land cover features in Dambatta LGA as at 2017. Figure 5 also shows that as at 2017, agricultural land decreased to about 17.7%, followed by vegetation cover at about 15.0%. Developed area had

increased to about 43.7%, bare land had also increased to 21.1%, while water body took 2.3% of the total land area. This result depicts that over a period of another 10years from 2007 to 2017 agricultural land in Dambatta LGA had further decreased by 27.8%, vegetal cover had reduced by 40.2% while developed area and bare land have increased by 30.6% and 13.9% respectively.

The graphical analysis in Figure 6 shows a cross section of land cover variation within a period of 20yrs from 1997 to 2017. Agricultural land had shown a progressive decrease in land cover over the 20 years under the study, it had shown a higher rate of decrease with over 50% decrease in the first 10 years between 1997 to 2017, while the rate of decrease in the last 10yrs had slowed down to about 27.8% between 2007 and 2017. It was also observed that agricultural land had shown a drastic overall decrease of 65.7% over the 20 years under the study. This implies that agricultural land had decreased to less than 3times its original size since 1997. Vegetation cover decreased at a slow rate of 10% in the first 10yrs within 1997 to 2007 and a higher rate of 40.2% decrease within 2007 to 2017 was observed. An overall decrease of 45.5% in vegetation cover was recorded over 20yrs from 1997 to 2017. This implies that vegetal cover had reduced to less than half its original size since 1997. Developed areas have shown a great increase of 147% between 1997 and 2007, this increase slowed down to 30.6% within the period. Over the 20 years of study, developed areas have shown a significant increase of 223.3%. This implies that developed areas have expanded to more than twice its original size since 1997. Dambatta LGA over the first 10 years from 1997 to 2007 had witnessed a significant increase in bare land up to about 140% of its original size. This increase slowed down to 13.9% in the last 10yrs between 2007 and 2017, while an overall increase of 173.8% over 20yrs was recorded. This implies that bare land had increased by almost twice its size since 1997. Water body had also increased by 70% over the 20yrs of the study.

This analysis depicts a general decrease in agricultural land and vegetation cover with a corresponding increase in developed area and bare land over a period of 20 years. The unprecedented increase in developed area over the 20years period may have led to urban heat island, which has had a consequential effect on vegetation cover. This phenomenon may have led to significant decrease in vegetation cover experienced in the last 20yrs, leading to an increase in bare lands. The bare lands were exposed to direct sun light and lack of replenishment of soil nutrient as a result of absence of vegetation cover leading to land degradation, with a consequential reduction in agricultural land as experienced over the 20yrs of the study.

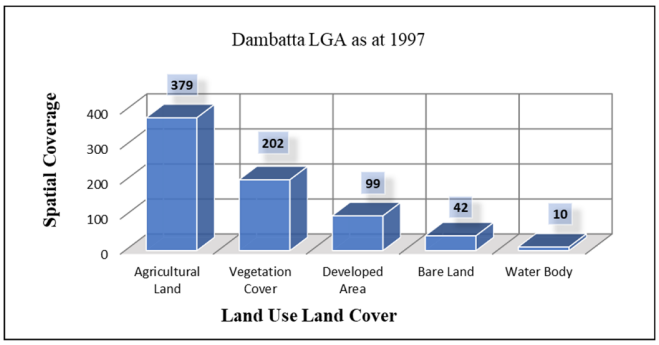

Figure 3: Estimated land cover distribution of Dambatta LGA as at 1997
Source**:** Authors' field work (2018)

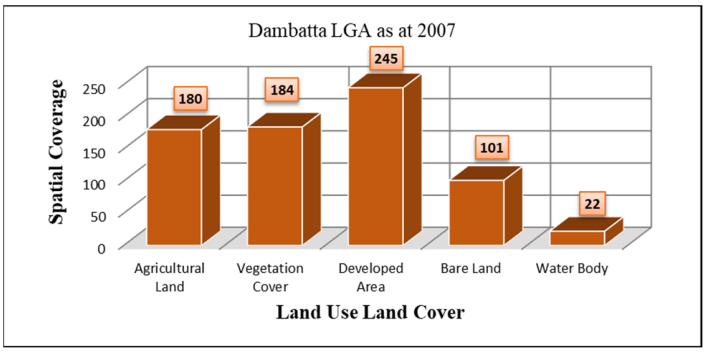

Figure 4: Estimated land cover distribution of Dambatta LGA as at 2007
Source: Authors' field work (2018)

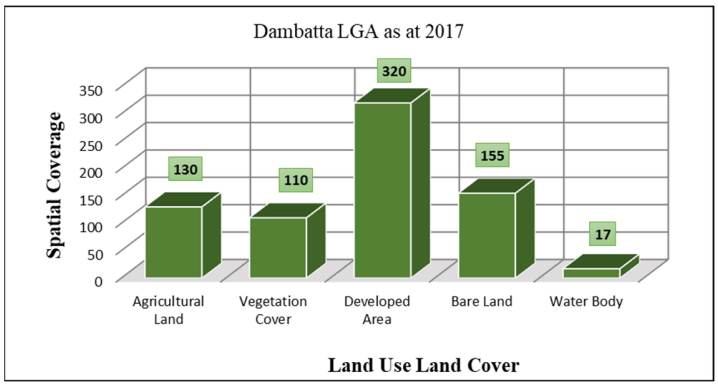

Figure 5: Estimated LC distribution of Dambatta LGA as at 2017
Source: Authors' field work (2018)

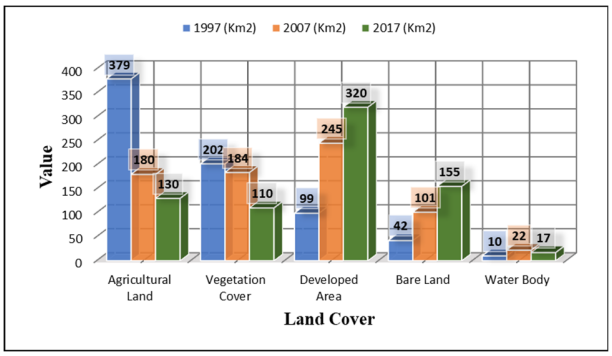

Figure 6: Rate of land cover change in Dambatta LGA between 1997 and 2017
Source: Authors' field work (2018)

Areas Requiring Intervention and Countermeasures

In order to identify, delineate and map the hotspot areas requiring intervention and countermeasures in the area, a composite LC map of 2017 and NDVI map of 2017 was created (Figure 7). This composite map was super imposed with the localities within Dambatta LGA, where the settlements requiring intervention were then drawn out. It was observed that agricultural land significantly decreased from 379km^2 to 130km^2 over the period under review (a significant change in land cover of about 249km^2), while bare land has increased at an accelerated rate by 113km^2. The areas covered by agricultural land and vegetation have been over taken by expanding bare lands and built-up areas at an unprecedented rate.

This is partly why the Land Cover information for 20 years indicates a major change. This indicates desert encroachment in the study area which has been occuring at the rate of 5.65km^2/yr over a period of 20years. This high rate of

bare land acceleration has led to severe land degradation and reduction in agricultural lands. It also aligns with the conclusion of 'the expansion of desert theory' by lampery (1975) that the Sahara was expanding at a rate of 5.5m/year

Results from the generation of the composite map, shows that almost all parts of the LGA require intervention. However, areas with serious land degradation include: Baushe, Gwalaida, Dambatta, Maiganji, Maisarake, Sansani, Tukue, Marke, Zage, Mesado, Gandu, Sarbi, Kwarkiya, Zedawa, Lautai, Kwaneria Kanawa, and Garin Dege. The settlements are located within the areas that are mostly affected by expansion of bare land and land degradation. The result was further confirmed by observations made during ground thruthing exercise (see plates 1, 2 and 3).

From the result of the analysis, the significant areas of landcover change were found within specific locations in Danbatta Local Government Area. This implies that there could be certain factors that might be responsible for the high incidences of land cover changes in the identified areas. These results can negatively affect farmers, ruler dwellers, urban development board, forest reserves and other policy makers. Hence intervention in these areas in the form of afforestation and prevention of the expansion of bare land is required.

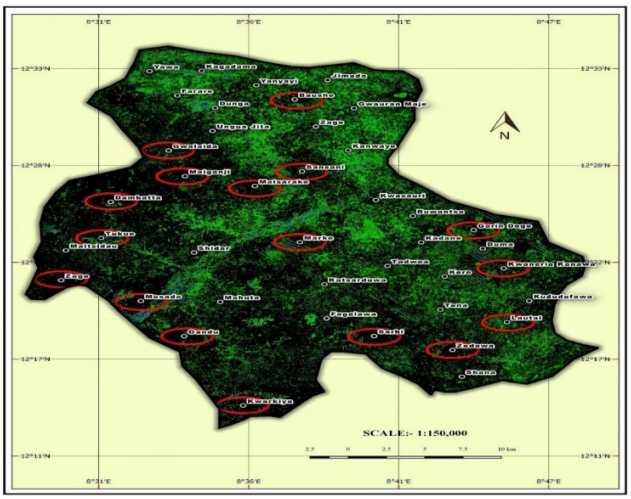

Figure 7: Areas requiring intervention and countermeasures in Dambatta LGA
Source: Author's field work (2018)

CONCLUSION

With respect to land degradation and deforestation, there was noticeable evidence of their consistent occurrence in most parts of Danbatta Local Government Area with major landmarks in the northeastern, central and southern parts of the area. However, the major land cover changes were found in Baushe, Gwalaida, Dambatta, Maiganji, Maisarake, Sansani, Tukue, Marke, Zage, Mesado, Gandu, Sarbi, Kwarkiya, Zedawa, Lautai, Kwaneria Kanawa, and Garin Dege. Therefore, it is recommended that there should be proper management of urban land use, in order to prevent disruption of natural ecosystem, and subsequent urban decay. Also, there is also a need for the application of remote sensing and GIS in the monitoring of land use and land cover of the area, so that necessary intervention could be made.

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