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ASSESSMENT OF DEFORESTATION IN BALI LOCAL GOVERNMENT AREA OF TARABA STATE, NIGERIA, USING GEOSPATIAL TECHNIQUES

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ABSTRACT

Deforestation is one of the leading environmental threat which causes a lot of negative impact to the environment resulting from excessive logging of trees, population growth and urbanization, bush fire, agricultural expansion and traditional medicine, lumbering and overgrazing for economic and other uses. The research aimed at assessing the level of deforestation at different epochs in the study area. It was achieved by performing Land use/ Land Cover for multiple time period using maximum likelihood algorithm. It also determined the rate of changes that occurred during the epoch, and it also assessed the level of deforesting. The methodology involves acquiring satellite imageries for multiple time periods, thus Landsat 7 ETM of 2010 and Landsat 8 OLI of 2015, 2020 and 2024 were employed. The satellite imageries were processed in ArcGIS, Land use Land Cover Classes were classified in to six different land cover classes, thus water Bodies, less dense vegetation, dense vegetation, built up areas, bare surface area and others. Image classification was used to detect alteration in land cover types. Area for land cover classes for the various epoch, 2010, 2015, 2020 and 2024 and percentage changes were obtained. Results obtained shows loss of vegetation cover by -63% from 2010 to 2024, while built up area, bare land, others were increasing as a result of population expansion. The loss of vegetation cover was as a result of urbanization, economic and agricultural expansion as a result of increase in population. It provided valuable insights into the dynamics of deforestation in the study area and recommended the integration of GIS and remote sensing technique to be employed to determine the causes of deforestation, its effect and how to mitigate it for sustainable environmental development.

Keywords: Geospatial Techniques, Deforestation, Bali, Change Detection.

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1.0 Introduction

Forest a valuable and significant component of ecosystem that support agriculture and other economic benefit have no doubt a significant part of human wellbeing. According to [10] Forest has been and contributing to income generation and food security for millions of people, especially in developing countries such as Africa and Nigeria in particular. Despite all these benefits, this Natural gift has faces serious degradation over time, the activity of deforestation is not a new phenomenon in Nigeria and the world at large. Deforestation is one of the leading environmental threat which causes a lot of negative impact to the environment resulting from excessive logging of trees, population growth and urbanization, bush fire, agricultural expansion and traditional medicine, lumbering and overgrazing for economic and other uses [13]. [7] Defined deforestation as the process of clearing, removing forest tree where the land is converted to other activities for non- forest use, such as residential or industrial area, road or rail construction, agricultural purposes and industrial use. Global forest watch [9], conclude that activities like infrastructural development, agriculture, tree logging and urbanization contribute to deforestation and result to a lot of effect on afforestation efforts. In recent years, the discovery of Rosewood tree locally known as Madobiya or Madrid tree in Hausa in part of Bali local Government area of Taraba state have attracted a lot of activities to the environment positively and negatively. The trend has continued for many years due to the high demand for rosewood timber by the Asian factories, leading to massive deforestation. The activities of the loggers have affected the forest and eventually the ecosystems in the area which is home to plants and wild animals. Forest are often subject to continued logging and harvest, producing a dynamic landscape of human use that threatens biodiversity especially of forest- obligate species [12]. Remote Sensing is the science and technology for attaining evidence about an object without making physical contact with the object [2]. [8] Used Landsat TM /ETM+ to detect land degradation in Tongyu county North East China. Change analysis of features of Earth's surface is essential for better understanding of interactions and relationships between human activities and natural phenomena. This understanding is necessary for better resource management and improved decision making [5]. Change detection is a system of recognising different in occurrences by checking it in different time [6]. LULC can be classified using gradable classification method; this approach improves the accuracy of classification when identifying LULC, [11].

The aim of this study is to assess the level of deforestation in Bali local government area of Taraba state. Although deforestation occurred in many parts of the country, the most adversely affect state is Taraba state and particularly the central zone [3, 4], but most affected local government in the zone and the state at large is Bali local government, these is confirmed by [1]. Despite this no study was conducted to assess deforestation in Bali local government in particular, previous studies may have focused on specific aspects of deforestation, such as land cover change or drivers of forest degradation, there remains a lack of integrated approaches that consider the interactions between socio-economic factors, land use dynamics, and environmental processes driving deforestation in the region, few studies have looked at the temporal and spatial dynamics by which those drivers act, which is important for assessing the preservation of biodiversity, there is a need for more detailed and accurate spatial data, including high-resolution satellite imagery, to improve the accuracy and reliability of deforestation assessments and inform effective conservation strategies. Addressing these research gaps will enhance our understanding of deforestation dynamics in the study area and facilitate the development of evidence-based policies and interventions to mitigate its adverse impacts on local ecosystems and communities.

1.2 Study Area

Bali local government area, the study area is located in the central part of Taraba state. It covers a total area of about 9,146km² and extend between latitude 7° 30 ' 00 " and 8° 10 ' 00 " north of the equator and longitude 5° 40 ' 00 " and 6° 15 ' 00 " east of the Greenwich Meridian, it boarders Ardo Kola and Gassol Local governments to the North, Donga and Kurmi local government in the West and Gashaka local government to the south. It also shares boundary with Adamawa state in the North-Eastern part. It has a climatic characteristic of tropical climatic condition characterized by wet and dry climate. The average vegetation of the study area is chiefly of the Guinea savannah vegetation dominated by Daniella Daniella and providing the limited amount of shade [14]. Rainfall distribution and topography are the most important factor influencing the pattern of vegetation in the study area with vigorous vegetation during wet season but their foliage wilt in dry seasons. Wide variety of shrubs and trees are also present. [10].

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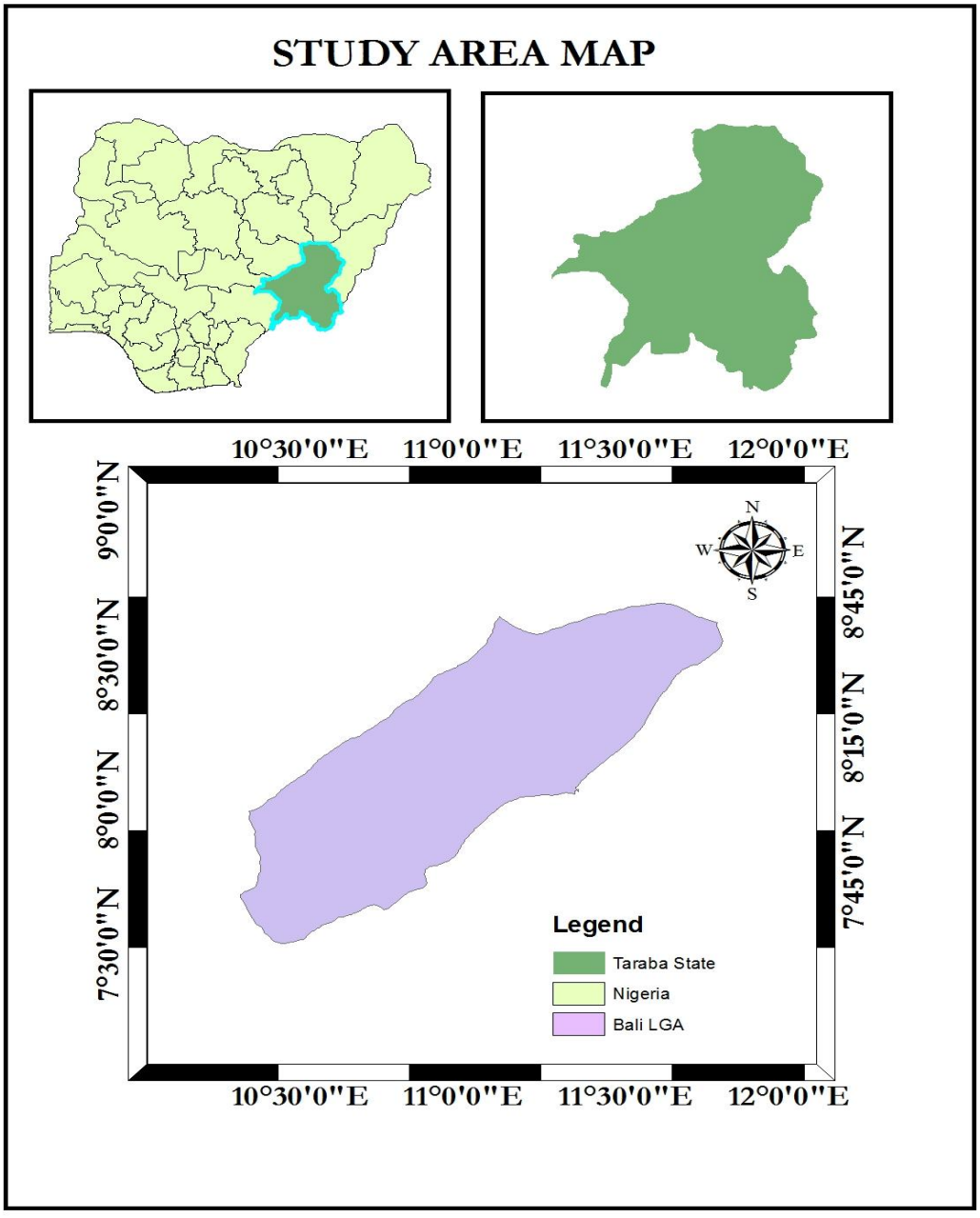

Figure 2.1 Map of the study area. (Source: Researcher's work)

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2.0 Materials and Methods

The materials and methods followed is shown in the flowchart of methodology below.

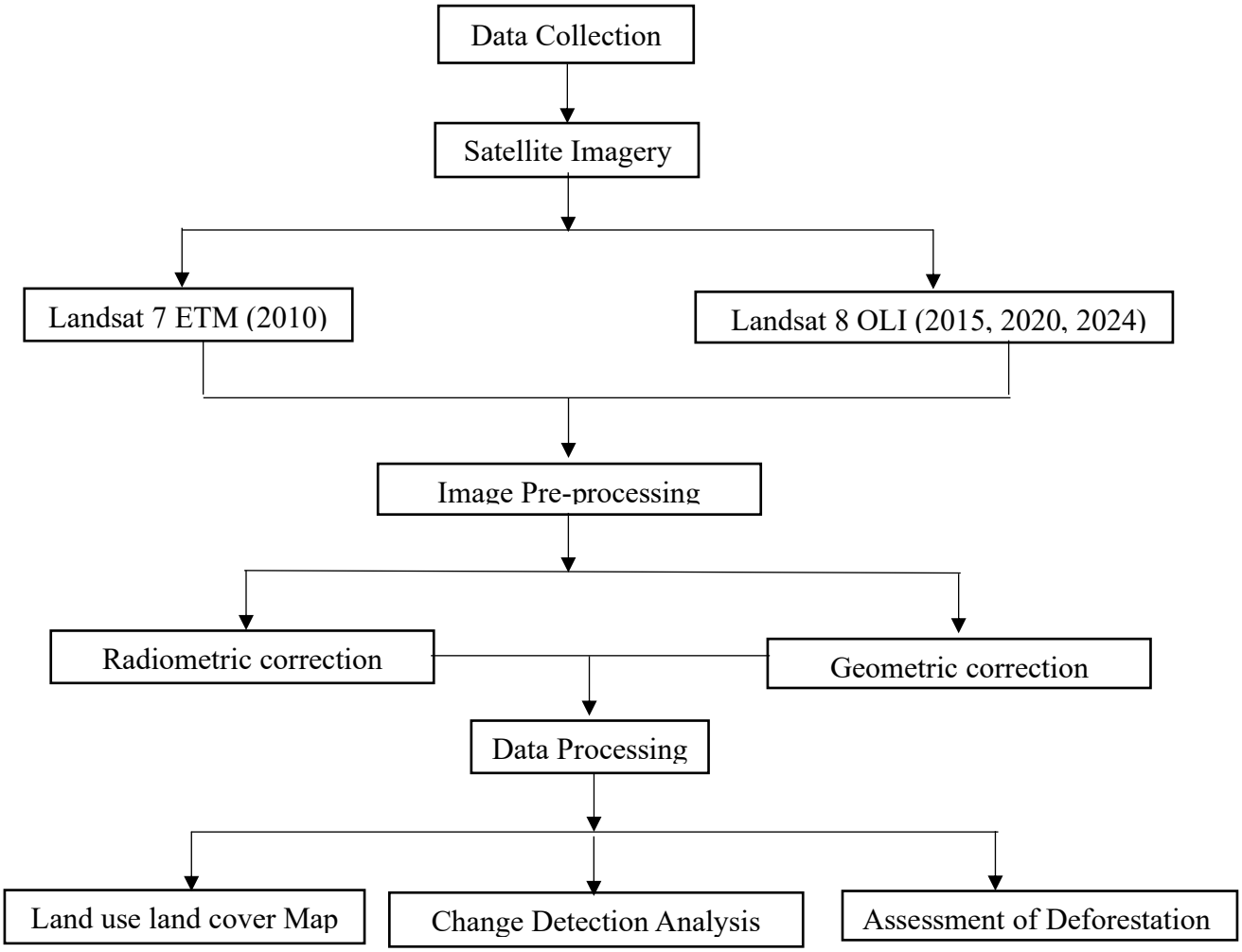

Figure 2.1 Flowchart of Methodology

2.1 Data Collection

Data collection in this research was made by acquiring satellite imagery of the study area. The satellite image used are Landsat imageries of 2010, 2015, 2020 and 2025. Landsat 7 ETM+ (Enhanced Thematic Mapper) image of February 2010, Landsat 8 OLI (Operational Land imager) of February 2015, Landsat 8 OLI (Operational Land imager) of February 2020 and Landsat 8 OLI (Operational Land imager) of February 2024. These are obtained from United State Geological

Survey (USGS) site (http://earthexplorer.usgs.gov) covering the study area. The images were used to determine the area extent of land use land cover coverage during the epochs.

2.2 Data Processing

Remote sensing data need to be pre-processed to remove any noise, correct for atmospheric effects, and convert it in to suitable format for further analysis. Radiometric and geometric correction were applied to an Image to account for atmospheric effects, sensor errors and geometric distortions. This was done using Erdas image. The satellite imageries were imported into ArcGIS. Environment. The image was layer stacked using the composite band tool in ArcGIS and merged as one image to have the information covered by bands in a single combine image of all bands. The process was repeated for all images. Using Mosaic to new raster tool in ArcGIS the image of the scene path was then merged into one Mosaic image to overlap the edges of the images. Maximum likelihood supervised image classification techniques was used in classifying the image into various classes. The method was employed due to prior knowledge of the area which enable guiding training data for the classification. Training data was generated to guide the classification based on the land use/ land cover themes presents in the area. The known land cover type was coded with the names of the corresponding thematic features. The classification was classified into six: Dense vegetation, less dense vegetation, bare land, water body, built up area and others. Deforestation can be identified by comparing land cover classifications over time. This can be done using change detection techniques, which involve comparing two or more land cover classification to identify areas that have changed, the land use land cover analysis involves the classification of satellite imagery covering multiple time periods for Bali Local Government Area in Taraba State. The classification process utilizes spectral signatures and training samples to accurately distinguish between different lands cover classes. The land Use Land Cover map of the study area was produced.

3.0 Result and Discussion

Bali local government area of Taraba state has undergone significant changes in its forest cover from 2010 to 2024. The land cover classes of the study area was characterized into six classes, namely, Bare land, Built up area, Water body, Dense vegetation, Less vegetation and Others as shown in figure 3.1, 3.2, 3.3 and 3.4 respectively. On the Total area occupied by each land cover

classes, Bare land increased from 53966.16 ha (2% of the total area) in 2010 to 183177.3 ha (21%) in 2024, this indicate a significant increase and can be attributed to agricultural activities such as crop farming, livestock rearing and other activities, this indicates cultivated areas which are very valuable for agricultural activities and food security. For the built up area, there is a slight increase in the area cover between 2010 and 2015, which is from 1% to 2% land cover, while in 2015 and 2020 built up area has 2% land cover each. It is interesting to note that the period between 2020 and 2024 saw intensified urban development, indicating a rapid expansion in both urban and infrastructure development. These can be observed in Table 3.3 and Table 3.4 were the built up area increased with 3% between 2020 and 2024. Water bodies, although they cover only a small portion of the land cover area, have shown increase in land cover from 2020 to 2024 by 3%, but the remaining epochs no changes experience as can be seen in Table 3.1, Table 3.2 and 3.3 respectively. The changes observed in water bodies could be attributed to climate change which might be as a result of changes in water management practices, or shifts in rainfall patterns. While the sixth class known as others, has increased throughout the epochs with 23% increase between 2010 and 2015, 10% between 2015 and 2020 and 2% between 2020 and 2024. This land cover class has a total area cover of 418255.7ha in 2010 (19%) and 481019.5 ha in 2024 (54%) as shown in Table 3.1 and Table 3.2 respectively. This indicate that the land cover class increased with 35% between 2010 and 2024.

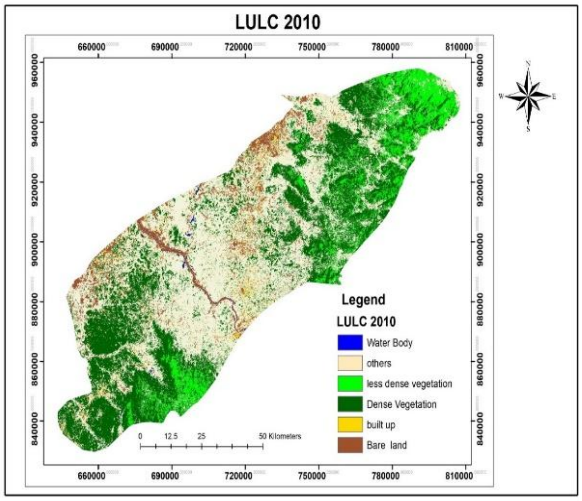

Figure 3.1 LULC Map of Bali 2010.

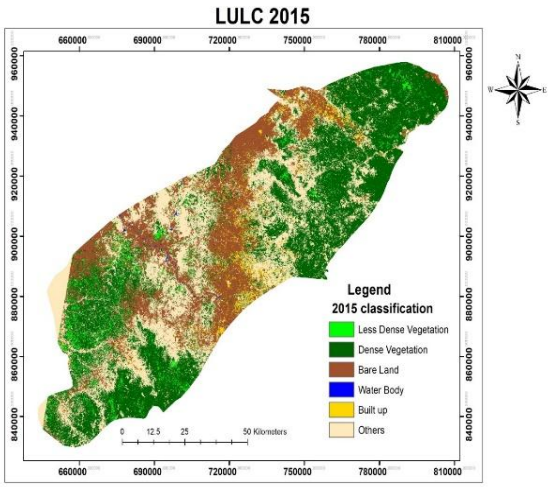

Figure 3.2 LULC Map of Bali 2015.

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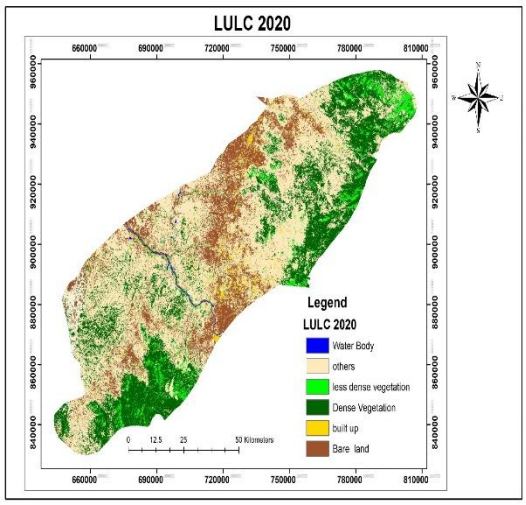

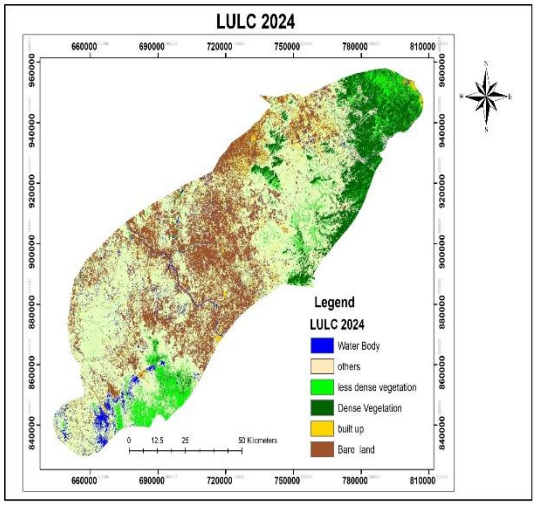

Figure 3.3 LULC Map of Bali 2020. **Figure 3.4 LULC Map of Bali 2024**

Table 3.1: Land Cover Class for 2010

Value	Class Name	Area (Hectare)	Percentage
1	Bare land	53966.16	2%
2	Build Up Area	14833.17	1%
3	Water Body	1835.82	1 %
4	Less Vegetation	86648.04	4%
5	Dense Vegetation	1576316	73%
6	Others	418255.7	19%
	TOTAL	2151854.89	100%

Table 3.2: Land Cover Class for 2015

Value	Class Name	Area (Hectare)	Percentage
1	Bare land	56392.41	6%
2	Build Up Area	17326.62	2%
3	Water Body	2350.8	1%
4	Less Vegetation	456426.2	4%
5	Dense Vegetation	41829.12	45%

6	Others	430640.09	42%
	TOTAL	1004965.24	100%

Table 3.3: Land Cover Class for 2020

Value	Class Name	Area (Hectare)	Percentage
1	Bare land	126784.89	15%
2	Build Up Area	20173.14	2%
3	Water Body	4186.62	1%
4	Less Vegetation	44818.92	5%
5	Dense Vegetation	219889.8	25%
6	Others	448895.79	52 %
	TOTAL	864749.16	100%

Table 3.4: Land Cover Class for 2024.

Value	Class Name	Area (Hectare)	Percentage
1	Bare land	183177.3	21%
2	Build Up Area	37499.76	5%
3	Water Body	35712.18	4 %
4	Less Vegetation	56501.46	6%
5	Dense Vegetation	91384.2	10%
6	Others	481019.5	54%
	TOTAL	885294.4	100%

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3.1 Rate of Change

The result for the rate of change was shown in Table 3.5, 3.6 and 3.7 shows respectively. Table 3.5 indicate changes in Land cover class, it can be seen that dense vegetation decreased from 73% to 45% having 28% land cover decrease between 2010 and 2015, this period is the highest changes dense vegetation cover experienced and it is the peak to which excessive logging of the rosewood plant experienced in the study area. The bare land also increased with 4% and the built up area increased with 1%. This suggest the impact of urban expansion as well as increase in agricultural activities within the study area. Other land cover classes increased in the same period with the exception of water Body and less dense vegetation where they maintain their percentage cover. Unlike in 2015 and 2020 epoch, the less dense vegetation increased with 1% from 4% to 5% as can be seen in Table 3.6, however water body still maintained no changes, other land cover classes such as bare land increased from 6% to 15% (9% increase), others increased with 10%, that is from 42% in 2015 to 52% in 2020. The dense vegetation in this epoch decreased from 45% to 20% (20% decrease). This indicate a great setback of the forest cover in Bali local government area during this epoch. Unlike the other land cover classes the water body and the built up area maintained their percentage cover. Epoch 2020 to 2024 as can be seen in table 3.7 shows a turning point for water body were it changes from 1% in 2020 to 4% in 2024. This may be as a result of changes in water management practices, or shifts in rainfall patterns. Also in this epoch the dense vegetation experienced a 15% decrease, while the less dense vegetation increased with 1% from 5% to 6%, bare land increased to 14%, built up area increased with 3% and others increased with 2% from 52% to54%.

Table 3.5 Rate of changes between 2010 and 2015.

Value	Class Name	2010	2015	Difference
1	Bare land	2%	6%	4 %
2	Build Up Area	1%	2%	1%
3	Water Body	1%	1%	0 %
4	Less Vegetation	4%	4%	0%
5	Dense Vegetation	73%	45%	-28 %
6	Others	19%	42%	23 %

Table 3.6: Rate of changes between 2015 and 2020

Value	Class Name	2015	2020	Difference
1	Bare land	6%	15%	9%
2	Build Up Area	2%	2%	0%
3	Water Body	1%	1%	0%
4	Less Vegetation	4%	5%	1%
5	Dense Vegetation	45%	25%	-20%
6	Others	42%	52%	10%

Table 3.7: Rate of changes between 2020 and 2024

Value	Class Name	2020	2024	Difference
1	Bare land	15%	21%	6%
2	Build Up Area	2%	5%	3%
3	Water Body	1%	4 %	3%
4	Less Vegetation	5%	6%	1%
5	Dense Vegetation	25%	10%	-15%
6	Others	52%	54%	2%

Table 3.5, 3.6 and 3.7 shows the rate of changes between 2010 and 2015, 2015 and 2020, 2020 and 2024, respectively, the difference was also obtained by subtracting the two epochs.

3.2 Assessment of level of deforestation from 2010 to 2024

The forest cover is characterized by the presence of dense vegetation cover. However, the results in this study shows continues decrease in dense vegetation cover throughout the epochs as shown in Table 3.2, 3.3 and 3.4 respectively. The highest decrease in the amount of dense vegetation within Bali occurred between 2010 and 2015, which is a period of rapid exploitation of rosewood plant. These areas decreased from 73% of the land cover in 2010 to 45% in 2024, a loss of 28%

as shown in Table 3.1 and 3.2. This areas which play a crucial role in the ecosystem and biodiversity experienced a significant amount of reduction, the reduction may negatively impact the ecosystem. Similarly findings in Table 2.1 and Table 3.4 shows that the forest has reduced in size from1576316 ha (73%) in 2010 to 91384.2 ha (10%) in 2024. Meanwhile, an increase of 1% was recorded by less vegetation between 2015 and 2020, with a total growth of 46564.262 ha, and another 1% between 2020 and 2024. However, there was no growth recorded by less vegetation between 2010 and 2015 as shown in Table 3.1 and Table 3.2. Bali local government area surfers the worst deforestation due to its accessibility by road linking its nooks and crannies from Dakka, Mayo-Kam, Garba-chede, Maihula and Sabon-Gida areas in corridor formation. This make it vulnerable because of the easy transportation of log from any place. [1]

Table 3.8: The Overall computation of changes between 2010 and 2024

Value	Class Name	2010	2024	Difference
1	Bare land	2%	21%	19%
2	Build Up Area	1%	5%	4%
3	Water Body	1%	4 %	3%
4	Less Vegetation	4%	6%	2%
5	Dense Vegetation	73%	10%	-63%
6	Others	19%	54%	35%

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4.0 Conclusion and Recommendation

This study has provided valuable insights into the dynamics of deforestation in Bali Local Government Area of Taraba State using geospatial techniques. Through land use land cover analysis and change detection, significant changes in land cover types, particularly deforestation, have been identified and analysed over multiple epochs. The findings highlight the drivers and impacts of deforestation, including agricultural expansion, urbanization, and infrastructure development, emphasizing the urgent need for effective conservation strategies. The study

emphasizes the importance of sustainable land management practices, policy interventions, community engagement, and capacity-building efforts to mitigate defforestation and preserve the ecological integrity of the region.

Based on the research conducted and the results obtained, the research recommends integrating machine learning algorithms with geospatial techniques for improved deforestation monitoring, also Taraba State government and other stakeholders can work collaboratively and proactively towards a more sustainable future, ensuring the protection and conservation of its valuable natural resources for generations to come. Research need to be carry out in finding the causes and the effect of deforestation. Lastly, applying geospatial technique to assess deforestation in this research contributes to the field of environmental monitoring and conservation, demonstrating the effectiveness of using high-resolution satellite imagery in detecting deforestation events, and providing a comprehensive assessment of deforestation dynamics in Bali local government area of Taraba state, Nigeria.

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