INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

Spatio-Temporal Classification of Land Use and Land Cover Changes between 1995 and 2025 of Idanre Forest Reserve, South-Western Nigeria

Obadun F. M, Adedeji E. T. and Adekunle V. A. J

Federal University of Technology, Department of Forestry and Wood Technology, Akure

DOI: https://doi.org/10.51244/IJRSI.2026.1307000088

Received: 10 July 2026; Accepted: 15 July 2026; Published: 29 July 2026

ABSTRACT

This study assessed the spatio-temporal dynamics of land use and land cover (LULC) changes in Idanre Forest Reserve, Ondo State, Nigeria, between 1995 and 2025 using Landsat imagery, Geographic Information System (GIS), and supervised Maximum Likelihood Classification to map six LULC classes which are undisturbed forest, disturbed forest, built-up land, bare land, bare rock and water bodies. The overall classification accuracies ranging from 87.7% to 91.2% and Kappa coefficients of 0.83–0.90. The results revealed a decline in undisturbed forest cover from 34,805 ha to 23,905 ha, representing a loss of 10,890 ha (273 ha yr^{-1}), accompanied by substantial increases in disturbed forest and bare land due to agricultural encroachment, illegal logging, and other anthropogenic activities, highlighting the need for strengthened forest protection, ecological restoration, and continuous geospatial monitoring to ensure the sustainable management of the reserve.

Keywords: Land use and land cover change, Remote sensing, GIS, Maximum Likelihood Classification, Forest degradation, Idanre Forest Reserve, Nigeria.

INTRODUCTION

Land use and land cover change represents the changes that are occurring over the cover as a result of human modification of its uses. It can also result from human driven natural processes such as climate change. LULCC can alter the terrestrial ecosystem and its ability to perform its provisioning and support services. Land use change (LUC) is a nonlinear process by which human activities transform the natural landscape. LUC is a regular and global phenomenon that combines natural and anthropogenic systems and influences air, soil and water (Fasona *et al*., 2020).

Global anthropogenic activities increase considerably and lead to large-scale modifications to the earth's surface, affecting the effectiveness of global systems. Consequently, the swift changes in LULC, specifically in low-income countries, have reduced important resources, such as water, soil, and vegetation (Ayeni and Odume, 2020). Due to their magnitude, they have become global critical implications, and it is alarming that those changing steps are increasing locally, regionally, nationally, and worldwide, and this may significantly impact the environment on a different level (Gudo *et al*., 2022).

Land-cover change and deforestation also result from direct, human-induced conversion of forested land to non-forested land uses including annual cropland, pasture or rangelands, perennial plants, and urban lands (GOFC-GOLD 2016). Moreover, human activities, such as mining, logging, urbanization, tourism, overgrazing and agricultural expansion have proximately engendered continual yet considerable loss of forests and their resources through deforestation and forest degradation (Hosonuma *et al*., 2012). These activities are principally associated with the processes of exploiting and converting forest (land) to meet human needs, while exacerbating the reduction of global forest area and their socio-ecological and carbon storage potential.

According to Lawson (2014), the unabatedly increasing global rate of deforestation and forest degradation has resulted in a significant reduction in forest cover, thereby limiting the capacity of the forests to sustain the provision of these valuable ecosystem goods and services, more prominently in the tropical developing nations.

INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

Changes in forest land use have a lot of implications on the environment from local to global level. These significant changes lead to local, regional, and global loss of biodiversity, rise in soil erosion, and sediment loads and irregularities in water cycle (Adedeji *et al*., 2020). Locally, changes in the use of land and its cover affect microclimatic resources, which have direct impacts on livelihoods of local communities (Sultan, 2016; Okeleye *et al*., 2023).

Despite its renowned historical, cultural, and ecological significance, Idanre Forest Reserve has not been spared from the growing impacts of anthropogenic activities. Over the years, the reserve has experienced a steady decline in forest cover, largely driven by agricultural expansion, shifting cultivation, illegal logging, and the conversion of forest land to other competing land-use uses (Orimaye *et al*., 2018). This continued degradation threatens the ecological integrity of the reserve and undermines its capacity to support biodiversity and provide essential ecosystem services.

Given the increasing rate of landscape transformation, there is a critical need to undertake periodic land use and land cover (LULC) assessments of Idanre Forest Reserve. According to Salem et al (2020), Spatio-temporal analysis using Remote Sensing (RS) and Geographic Information Systems (GIS) provides an effective approach for monitoring changes in forest extent, identifying the drivers and patterns of land cover transitions, and predicting future landscape dynamics. Such information is essential for evidence-based forest management, biodiversity conservation, sustainable land-use planning, and the formulation of policies aimed at mitigating further forest degradation while ensuring the long-term ecological sustainability of the reserve.

MATERIALS AND METHODS

Study Area

Idanre Forest Reserve is 574 km2 and is surrounded by Akure-Ofosu Forest Reserve and Ala Forest Reserve. The forest reserve is located in Ondo state's lowland forest zone, between latitude 6^{o} 45’ and 06^{o} 58’ 32’’N and longitude 04^{o} 59’ 59’15’’E and 05^{0} 12’ 4’. The forest reserve receives an average of 1654mm of rainfall per year, and the proportion of forest loss as of 2013 is 69% (Ikemeh, 2013). Idanre Forest Reserve is home to a diverse range of fauna species, including huge animal populations, as well as flora species. The forest reserve is one of the reserves that provide excellent opportunities for maximizing the country's ecotourism potential. Thus, the entire natural community of Idanre Forest Reserve is critical to the proper development of Idanre Hill, a planned cultural monument. The site has developed alongside its natural community, serving as a recruitment source for the site's distinctive flora and fauna (Ikemeh, 2013).

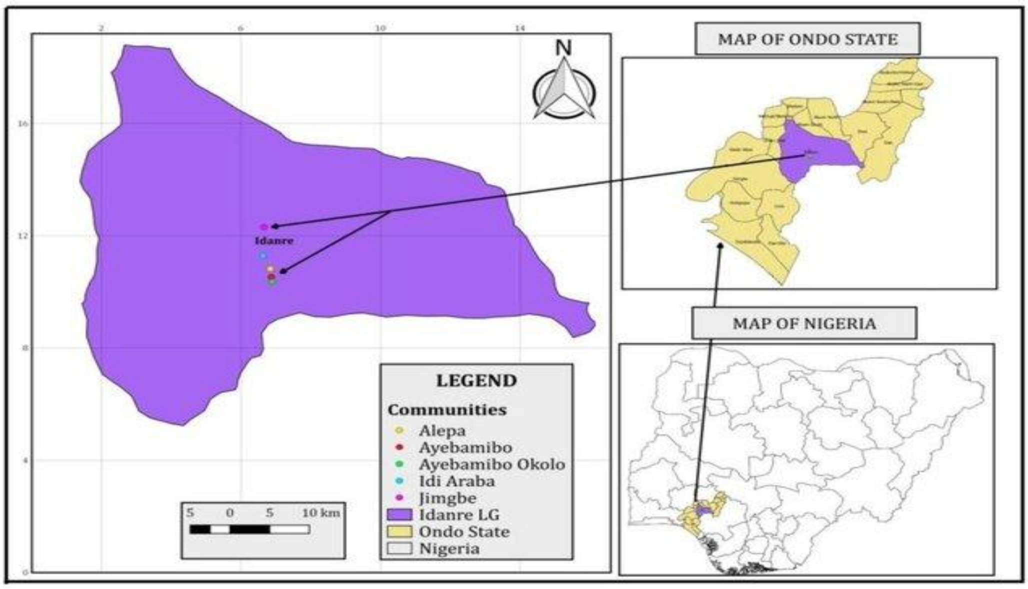


Fig 1: Map of Nigeria showing Ondo State, and Ondo State showing Idanre local Government Area where Idanre Forest Reserve is located

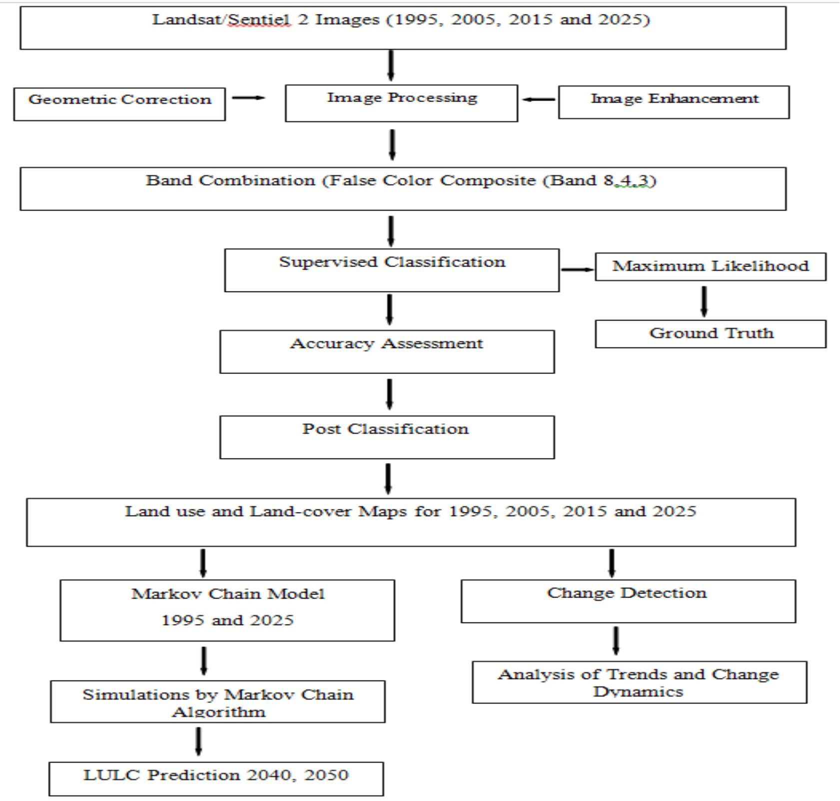
Data Collection

The study adopted two data sources namely primary and secondary data. The primary data involved the use of a handheld global positioning system (GPS) device. It was used to obtain the coordinates within the forest reserve for mapping the area where anthropogenic and illegal activities have taken place. Twenty (20) Ground Truth Points were collected from each six (6) different land uses and land covers identified in the field using Geographic Positioning System (GPS). Secondary data in the form of imageries were sourced from the Landsat missions which are the thematic mapper (TM), enhanced thematic mapper plus (ETM+) and the operational land imager (OLI). The cloud free multispectral Landsat (TM, ETM+ and OLI) imagery data were obtained from the United States Geological Survey (USGS) Earth-Explorer website https://earthexplorer.usgs.gov/. The data cover a period of thirty years (1995-2025) and the sources and properties of the imageries obtained in 1995, 2005, 2015 and 2025 are shown in Table 1. The methods adopted in this research are presented in the following major steps. These include downloading of Landsat satellite images, from USGS online data archive; clipping of the area of interest, and digital image processing.

Data Analysis

The acquired landsat imageries were pre processed for geometric and radiometric corrections, geo-referenced to the World Geodetic System (WGS) 1984 ellipsoid using Ground Control Points (GCP) gotten with GPS and then projected to zone 32N coordinate system of the Universal Transverse Mercator (UTM). Bands 8, 3, 4 for Landsat TM and ETM+ OLI were employed for false colour composite operation (Abegunde and Adedeji, 2015). Supervised classification was further carried out on the false colour composite using the Maximum Likelihood Classification Technique. Area of interest was extracted using extract by mask tool in ArcGis software 10.7.1. Six land use and land cover classes (undisturbed forest, disturbed forest, bare rock, bare land, water and built-up land) were identified and classified following Anderson's (1976) image classification scheme. Confusion Matrix using the ground truth points and Google Earth were used to determine the accuracy of the LULCC classification. Post classification approach was used to evaluate the spatio-temporal changes from 1995-2025. The area coverage of each LULC class and differences were calculated in ArcGis software. The results are presented in maps, charts and tables. Below (Fig. 2) is the flow chart of the methodology used.

Figure 2: Flow chart of LULC classification, prediction and change detection



ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

Table 1: Properties of Landsat Imageries used for the study

	1995	2005	2015	2025
Scene	LT04_L1TP_190055_19910105	LE07_L1TP_190055_20030207	LC08_L1TP_190055_20150115	LC08_L1TP_190055_20250110
Path	190	190	190	190
Row	55	55	55	55
Space Craft ID	Landsat 4	Landsat 7	Landsat 8	Landsat 8
Sensor ID	TM	L7_ETM+	OLI_TIRS	OLI_TIRS
Spatial Resolution	30m	30m	30m	30m
Acquisition Date	1991-01-05	2003-02-07	2015-01-15	2025-01-10
Datum	WGS84	WGS84	WGS84	WGS84
UTM	31	31	31	31

RESULTS

This study identified six land use and land cover classes in the year 1995, 2005, 2015, 2025. Fig. 3a, shows the land use and land cover of the Idanre Forest Reserves in the year 1995. It reveals that significant portion of the forest estate comprises of undisturbed forest, low disturbed forest, low built up land, bare rock and bare land and water body. Similar pattern was observed in the year 2005 and 2015 classification as seen in Fig. 3b and c with observable increase in disturbed forest, built up land, bare rock and bare land. However, Fig 3d revealed that in the year 2025, a prominent significant portion of the forest estate is made up of disturbed forest and built up land, with a significant bare land which indicates a significant loss in the undisturbed portion of the forest compare to the year 1995, 2005 and 2015. Bare lands and water body were on a high increase, with subsequent decrease in dense and sparse vegetation. Built up area was minimal at first in 2005 but slightly increased in 2015, 2025. An indication of encroachment was generally observed.

The area coverage of different land use and land cover classes within the study periods were presented in Figs. 3a-d. It was observed that out of 54,809 ha of the entire Idanre Forest Reserve in 1995, undisturbed forest covered 34,805 ha, disturbed forest 8299 ha, built up land 1929 ha, bare rock, 4497 ha, bare land 221 ha, water body 5,058 ha. It was observed that undisturbed forest decrease significantly between 1995 and 2025 by 10, 890 ha. However, disturbed forest increase from 8299 ha to 13,725 ha respectively.

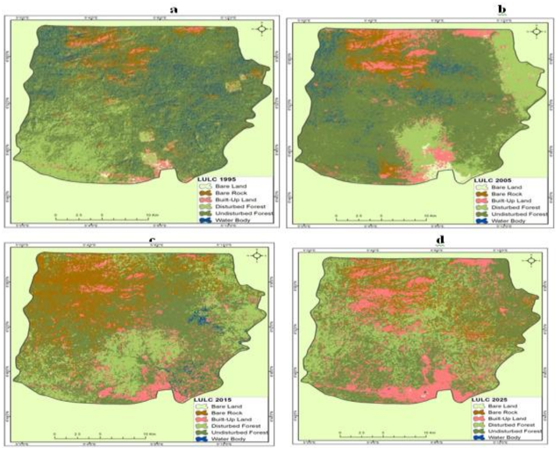


Fig. 3a-d: LULC Map of the Idanre Forest Reserve (1995, 2005, 2015 and 2025)

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

Confusion Matrix tables for accuracy of the LULC classification assessment are presented in Tables 2 to 5. The overall accuracy for 1995, 2005, 2015, 2025 were 88.2, 90.7, 87.7, and 91.2, and the Kappa Coefficient Values were 83%, 88%, 84% and 90% for 1995, 2005, 2015 and 2025 respectively.

Table 2: Confusion Matrix of overall accuracy and kappa statistics for Idanre Forest Reserve LULC 1995

Classified Data	**BR**	**BL**	**BUL**	**DF**	**WB**	**UF**	**Row Total**	**User's (%)**
BR	63.13	0.00	0.43	0.00	0.00	6.55	1595	93.2
BL	0.00	97.14	3.43	1.89	0.00	0.00	238	91.5
BUL	1.58	1.90	94.86	1.47	0.00	0.27	519	79.6
DF	0.14	0.95	1.28	95.47	0.00	1.91	1252	84.6
WB	15.78	0.00	0.00	0.00	86.67	21.52	3911	92.1
UF	19.37	0.00	0.00	1.16	13.33	69.75	12425	88.3
Column Total	697	210	467	950	15	17601	19940	
Overall accuracy	88.2							
Kappa Coefficient	83							
Kappa%	83%							

Table 3: Confusion Matrix of overall accuracy and kappa statistics for Idanre Forest Reserve LULC 2005

Classified Data	**DF**	**BL**	**BUL**	**BR**	**WB**	**UF**	**Row Total**	**User's Accuracy (%)**
DF	98.72	0.22	1.34	0.00	0.00	0.09	4965	85.2
BL	0.64	99.34	0.70	0.00	0.00	0.00	497	94.2
BUL	0.56	0.44	95.65	4.45	0.00	0.22	1923	89.5
BR	0.00	0.00	2.31	86.44	0.00	7.83	3069	94.6
WB	0.00	0.00	0.00	1.38	55.00	14.80	3509	91.1
UF	0.00	0.00	0.00	7.73	45.00	77.07	18242	89.3
Column Total	4983	455	1861	1372	20	23514	32205	
Overall Accuracy	90.7							
Kappa coefficient	0.88							
Kappa %	88							

Table 4: Confusion Matrix of overall accuracy and kappa statistics for Idanre Forest Reserve LULC 2015

Classified Data	**DF**	**BR**	**BL**	**WB**	**BUL**	**UF**	**Row Total**	**User's Accuracy(%)**
DF	96.51	1.61	0.00	0.00	0.49	3.26	2295	81.2
BR	0.40	79.98	0.00	0.00	13.70	29.03	9193	88.3
BL	0.00	0.00	100.00	0.00	1.82	0.00	201	89.1
WB	0.00	0.00	0.00	100.00	0.15	1.32	353	85.4
BUL	0.87	4.95	0.00	0.00	79.65	1.65	8794	93.3
UF	2.22	13.46	0.00	0.00	4.19	64.73	16329	88.7
Column Total	1489	869	10	15	10466	24316	37165	
Overall Accuracy	87.7							
Kappa coefficient	0.84							
Kappa%	84							

Table 5: Confusion Matrix of overall accuracy and kappa statistics for Idanre Forest Reserve LULC 2025

Classified Data	UF	DF	BL	BUL	BR	WB	Row Total	User's Accuracy (%)
UF	92.14	2.28	0.00	2.49	13.09	0.00	3754	95.1
DF	2.71	95.43	0.00	0.45	2.09	0.00	1649	89.7
BL	0.00	0.00	95.45	0.44	0.00	0.00	103	95.3
BUL	1.18	0.46	4.55	92.44	5.50	0.00	17488	85.3
BR	3.97	1.83	0.00	3.83	79.32	0.00	1190	92.3
WB	0.00	0.00	0.00	0.36	0.00	100.00	87	89.3
Column Total	3472	1533	22	18843	382	19	24271	
Overall Accuracy	91.2							
Kappa coefficient	0.90							
Kappa %	90							

Observed Changes in the Area Coverage of Different LULC Categories within the Study Periods.

The observed changes in the Area Coverage of Different LULC categories were presented in Table 6 and figure 4a-c. From 1995 to 2005, 1,792 ha of undisturbed forest and 2,607 ha of water body at the decreasing rate of 179ha/yr and 261 ha/yr were lost to disturbed forest and built up land, bare rock and land respectively. Disturbed forest gain 1,729 ha (18.55%), built up land gained 3,069 ha (32.85%), bare rock gain 7 ha (0.75%) and bare

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

lands gained 550 ha (5.90%). In other words, disturbed forest and bare lands increased with decrease in undisturbed forest and water body from 1995 to 2005. Similarly, between 2005 to 2015, undisturbed forest loss of 8,055 ha, water body 2,022 ha and bare land loss 642 ha respectively. The disturbed forest gain 2,004 ha, bare rock (7,728) and built up land gained 972 ha, at the increasing rate of 201 ha/yr, 97 ha/yr and 773 ha/yr respectively. Between 2015 and 2025, the undisturbed forest loss 1043 ha, bare rock 5,996 ha, bare land 92ha and water body loss 395 ha while the disturb forest gained 1,705 ha and built up land gained 5,841ha respectively.

Table 6: Change Detection from 1995 to 2005; 2005-2015; 2015 – 2025

Land Classes	1995 (ha)	2005 (ha)	Change Observed	Rate of Change ha/yr	%change observed	Remark
Undisturbed Forest	34,805	33,013	-1,792	179	19.23	Loss
Disturbed Forest	8,299	10,028	1,729	173	18.55	Gain
Built up land	1,929	4,990	3,061	306	32.85	Gain
Bare Rock	4,497	4,571	74	7	0.79	Gain
Bare Land	221	771	550	46	5.90	Gain
Water body	5,058	2,451	2,607	261	2.80	Loss
	2005 (ha)	**2015 (ha)**				
Undisturbed Forest	33,013	24,958	8,055	806	37.60	Loss
Disturbed Forest	10,028	12,032	2,004	201	9.35	Gain
Built up land	4,990	5,962	972	97	4.53	Gain
Bare Rock	4,571	12,299	7,728	773	36.07	Gain
Bare Land	771	129	642	64	3	Loss
Water body	2,451	429	2,022	202	9.44	Loss
	2015	**2025**				
Undisturbed Forest	2,4958	23,915	1,043	104	6.92	Loss
Disturbed Forest	12,032	13,735	1,703	170	11.30	Gain
Built up land	5,962	11,803	5,841	584	38.76	Gain
Bare Rock	12,299	6,303	5,996	4,996	39.78	Loss
Bare Land	129	37	92	9	0.61	Loss
Water body	429	21	395	40	2.62	Loss

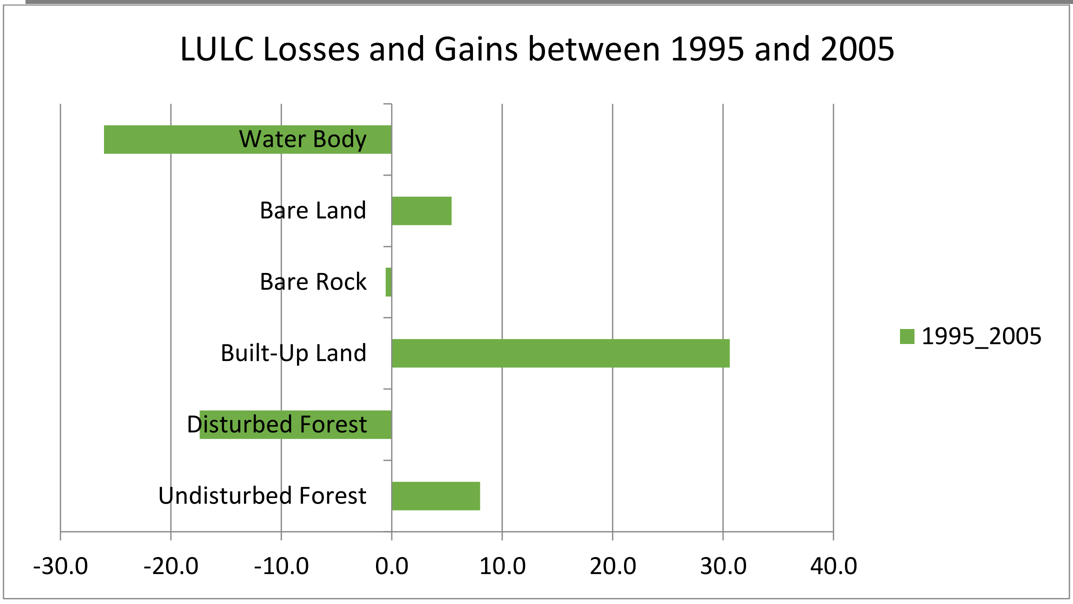


Figure 4a: LULC Losses and Gains between 1995 and 2005

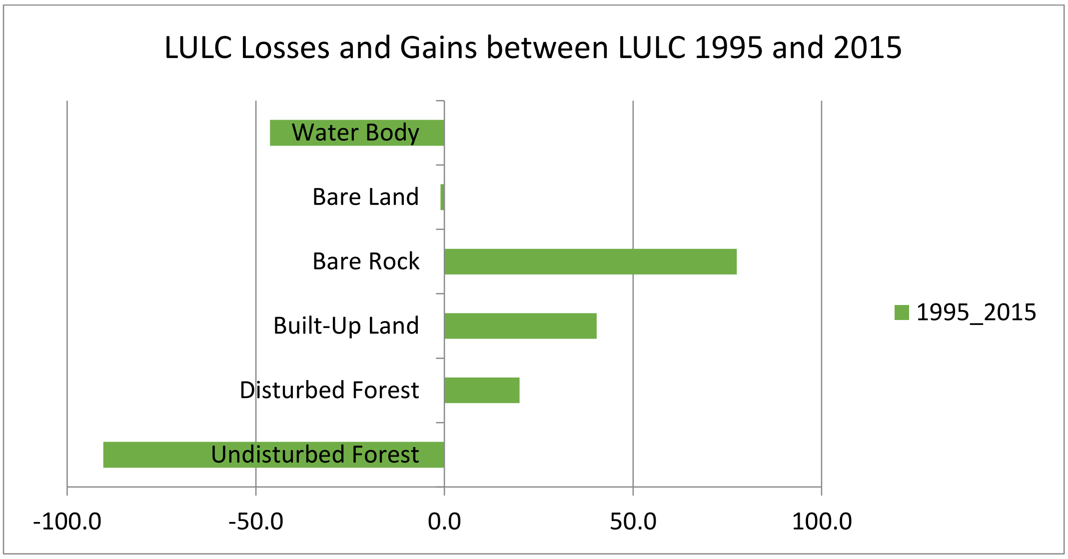


Figure 4b: Idanre Forest Reserve LULC Losses and Gains between 1995 and 2015

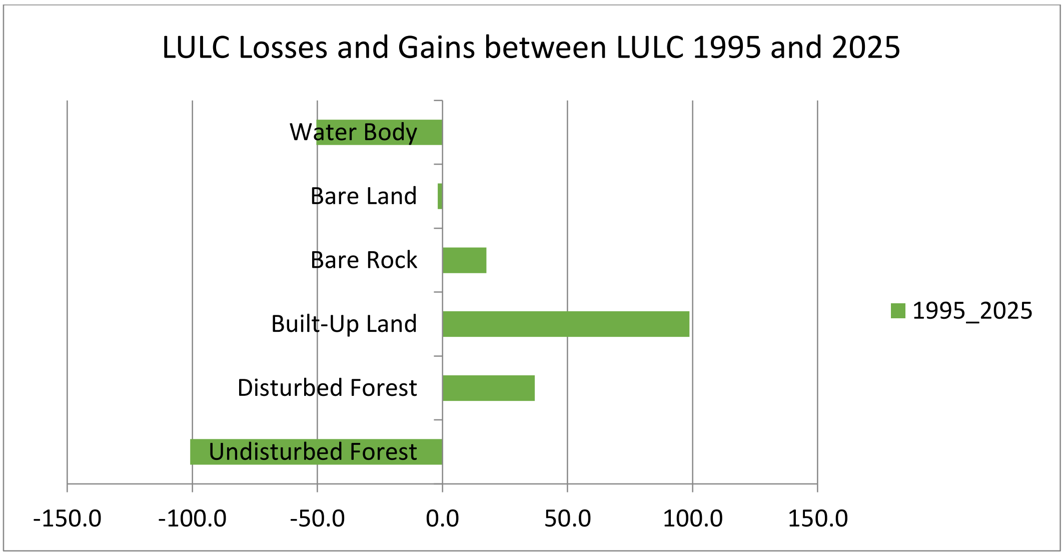


Figure 4c: Idanre Forest Reserve LULC Losses and Gains between 1995 and 2025

DISCUSSION

Idanre Forest Reserve exhibits distinct land use and land cover classification, namely undisturbed forest, disturbed forest, built up land, bare land, bare land and water body. The disturbed forest and bare land categories encompasses areas previously covered by undisturbed forests that have been converted for agricultural activities, along with exposed rocks, open land, transition zones, and areas with sparse grasses. Over the past several decades, there has been increasing global concern regarding the accelerated loss and degradation of forest ecosystems driven by rapid population growth, agricultural expansion, and other anthropogenic land-use activities in tropical forest (IPCC, 2019; FAO, 2020). The Idanre Forest Reserve is not insulated from these global and regional trends. Over the years, the reserve has experienced a progressive decline in forest cover, primarily due to agricultural encroachment, shifting cultivation, illegal logging, and the conversion of forest land to other competing land-use categories (Orimaye et al., 2018).

The findings of the study reveal that the undisturbed forested areas decreased from 34,805 ha in 1995 to 23,915 ha in 2025, translating to a loss of 10,890 ha over a 40 years period. Despite its outstanding cultural and ecological significance, characterized by its distinctive inselbergs, remarkable rock formations, and historical heritage, and despite its designation as a protected area, the Idanre Forest Reserve has experienced a pronounced decline in forest cover, with an estimated average loss of 273 ha yr^{-1}. The progressive depletion of undisturbed forest ecosystems has triggered substantial land-cover transitions, particularly the expansion of disturbed forests and bare surfaces. These two land-cover classes account for over 60% of the total area lost, indicating an advanced stage of forest fragmentation and degradation. The observed pattern suggests that anthropogenic activities, particularly agricultural encroachment and unsustainable land-use practices, continue to undermine the ecological integrity and conservation objectives of the reserve. This findings correlate with the report of Ubakwe et al (2022) who reported that the undisturbed forest decrease with time and the gained its experience, accompanied by an increase in agricultural land, built-up areas, and other anthropogenic land uses.

The analysis, supported by ground-truth observations, reveals a substantial expansion of disturbed forests and bare land areas, including converted agricultural lands, exposed soils, and grasslands, over the study period. The area classified as disturbed forest increased from 8,299 ha in 1995 to 13,735 ha in 2025, representing a cumulative gain of 5,436 ha during the period under review. Similarly, built up land expanded significantly from 1,929 ha in 1995 to 11,803 ha in 2025, reflecting an overall increase of approximately 9874 ha. These trends highlight the progressive transformation of natural forest ecosystems into degraded and anthropogenically modified landscapes. This findings corroborated the report of Bukoye et al (2023) that the bare land category, including converted agricultural lands, open soil, and grassland, has considerably expanded over the years.

Accuracy assessment is essential in land cover classification and change detection because it evaluates the reliability and validity of classified maps. An overall classification accuracy of 85%–100% is generally considered acceptable for LULC studies (Anderson 1976). In this study, the classification produced high overall accuracies ranging from 87.7% to 91.2%, with Kappa coefficients between 0.83 and 0.90, indicating excellent agreement and reliable LULC mapping. The high accuracy achieved can be attributed to the supervised Maximum Likelihood Classification technique, which is widely recognized for its superior performance compared to several other classification algorithms (Mahmon et al., 2015). The accuracy results obtained for Idanre Forest Reserve are consistent with findings from similar studies. Generally, the results showed that land use and land cover of the reserve have been on continuous state of transformation as a result of various anthropogenic and natural processes.

CONCLUSION

The study revealed significant spatio-temporal changes in the land use and land cover of Idanre Forest Reserve between 1995 and 2025. The study identifies six major land use and land cover classes within Idanre Forest Reserve, namely undisturbed forest, disturbed forest, built-up land, bare land, bare rock and water bodies. LULCC analysis revealed continuous decline in undisturbed forest cover and a corresponding increase in disturbed forest and bare land areas. The reserve lost approximately 10,890 ha of undisturbed forest, mainly due to agricultural encroachment, illegal logging, and other anthropogenic activities, indicating increasing forest degradation and fragmentation. The high classification accuracy (87.7–91.2%) and Kappa coefficients (0.83–0.88) confirm the reliability of the findings and provide a sound basis for sustainable forest management and conservation planning.

RECOMMENDATION

Forest protection and enforcement measures should be strengthened to control agricultural encroachment, illegal logging, and other unsustainable land-use activities within the reserve. Degraded areas should be restored through reforestation and afforestation programmes, while local communities should be actively involved in participatory forest management and conservation initiatives. Furthermore, continuous monitoring of land use and land cover changes using remote sensing and GIS technologies should be institutionalized to support effective decision-making and long-term conservation of the reserve.

REFERENCES

1. Adedeji, E. T., Jayeola, K., Akinbowale, A. S. and Tolorunju, M. S. (2020). Assessment of Physicochemical and Microbial Properties of Soil of a Disturbed Forest in Ondo State, Nigeria. Plants and Environment, 2(2): Pp 74-79.
2. Amoo, G. O, Martins Anyanwu, M. C. (2023). Prioritization of Protected Area Development in the Adjoining Communities to Idanre Forest Reserve, Ondo State, Nigeria. World Environmental Conservation Conference 2023, Climate Change Partnership Actions For Sustainable Future And Restoring Life On Earth, Federal University of Technology Akure.
3. Ayeni, A.O. and Odume, J.I. (2020) Analysis of Algae Concentration in the Lagos Lagoon Using Eye on Water and Algae Estimator Mobile App. FUTY Journal of the Environment, 14, 105-115.
4. Bukoye, J. , Oluwajuwon, T. , Alo, A. , Offiah, C. , Israel, R. and Ogunmodede, M. (2023) Land Use Land Cover Dynamics of Oba Hills Forest Reserve, Nigeria, Employing Multispectral Imagery and GIS. Advances in Remote Sensing, 12, 123-144.
5. Fasona, M.J., Akintuyi, A.O., Adeonipekun, P.A., Akoso, T.M., Udofia, S.K., Agboola, O.O., Ogunsanwo, G.E., Ariori, A.N., Omojola, A.S., Soneye, A.S. and Ogundipe, O.T. (2020) Recent Trends in Land-Use and Cover Change and Deforestation in South-West Nigeria. GeoJournal, 87, Pp 1411-1437
6. Food and Agriculture Organization (FAO). (2020). Global Forest Resources Assessment 2020: Main Report. Rome: FAO.
7. GOFC-GOLD, (2016). A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation. GOFC-GOLD Report version COP22–1, (GOFC-GOLD Land Cover Project Office, Wageningen University, The Netherlands).
8. Gudo, A.J.A., Deng, J. and Qureshi, A.S. (2022). Analysis of Spatiotemporal Dynamics of Land Use/Cover Changes in Jubek State, South Sudan. Sustainability, 14, Article No. 10753.
9. Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013). High-resolution global maps of 21st century forest cover change. Science, 342(6160), 850–853.
10. Hosonuma, N., Herold, M., De Sy, V., De Fries, R.S., Brockhaus, M., Verchot, L., et al. (2012). An Assessment of Deforestation and Forest Degradation Drivers in Developing Countries. Environmental Research Letters, 7, Article ID: 044009.
11. Hossain, M.S., Khan, M.A.H., Oluwajuwon, T.V., Biswas, J., Rubaiot Abdullah, S.M., Tanvir, M.S.S.I., Munira, S. and Chowdhury, M.N.A. (2023) Spatiotemporal Change Detection of Land Use Land Cover (LULC) in Fashiakhali Wildlife Sanctuary (FKWS) Impact Area, Bangladesh, Employing Multispectral Images and GIS. Modeling Earth Systems and Environment, 9, 3151-3173.
12. Ikemeh, R. A. (2013). Sustainable forest management in a human dominated landscape and its implications for biodiversity conservation: a Nigerian lowland forest perspective, Research and Reports in Biodiversity Studies, 9-23, DOI: 10.2147/ RRBS.S35442. https://doi.org/10.2147/RRBS.S35442.
13. Intergovernmental Panel on Climate Change (IPCC). (2019). Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.
14. Lawson, S. (2014) Illegal Logging in Papua New Guinea. Chatham House, London.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VII July 2026

15. Mahmon, N.A., Ya'acob, N. and Yusof, A.L. (2015) Differences of Image Classification Techniques for Land Use and Land Cover Classification. 2015 IEEE 11th International Colloquium on Signal Processing & Its Applications (CSPA), Kuala Lumpur, 6-8 March 2015, 90-94.
16. Okeleye, S.O., Okhimamhe, A.A., Sanfo, S., Fürst, C. (2023). Impacts of Land Use and Land Cover Changes on Migration and Food Security of North Central Region, Nigeria. Land, 12, 1012.
17. Orimaye, J. O., Ogunjemite, B. G., Ojo, V. A., Goni, I. M. and Olayanju, O. A. (2018). Land use and Land Cover Change in Idanre Forest Reserve, Nigeria: Implications on Primate Population. Nigerian Journal of Wildlife Management, 2(2): Pp1-12.
18. Salem, M., Tsurusaki, N. and Divigalpitiya, P. (2020). Land Use/Land Cover Change Detection and Urban Sprawl in the Peri-Urban Area of Greater Cairo since the Egyptian Revolution of 2011. Journal of Land Use Science, 15, 592-606.
19. Sultan, R.M. (2016). The impacts of agricultural expansion and interest groups on deforestation: An optimal forest control model. Int. J. Agric. Resour. Gov. Ecol., 12, 137–154
20. Ubaekwe, R. E., Chima, U. D. and Eguakun, F. S. (2022). Spatio-Temporal Classification and Prediction of Land Use and Land Cover Change in Finima Nature Park Bonny Island, Nigeria. Journal of Geography, Environment and Earth Science International, 26(8): Pp 40 53.