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ORIGINAL RESEARCH ARTICLE

Land use and forest cover change dynamics in Dambwa Local Forest Reserve, Livingstone, Zambia: A 40-year remote sensing and socioeconomic analysis (1984–2024)

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Abstract

Forests are crucial ecological assets that provide essential ecosystem services. However, human settlements and other drivers have led to land use and forest cover change (LUFCC). The study aims to assess LUFCC, identify its drivers, and evaluate the effectiveness of participatory forestry management between 1984 and 2024. The research used a spatiotemporal, quantitative, qualitative, and field observation approach. Change detection and analysis were performed using Landsat 5 Thematic Mapper and Landsat 8 Operational Land Imager/Thermal Infrared Sensor imagery from 1984 to 2024. Land cover classification was used to detect forest cover change (increases or decreases). LUFCC classes were generated into maps for each year. Furthermore, ground-truthing data (38 sites) were collected using a global positioning system. Primary data were collected using interviews (180 respondents), key informants' interviews, and focus group discussions. The study found a forest cover change of 8.7% with an annual rate of 0.22%. The percentage change per class was: forest (60.18%), settlement (8.03%), grassland (31.63%), and cropland (0.16%). The driving factors of LUFCC, as identified by respondents, were: settlement (45%), population growth (25%), infrastructure development (20%), agriculture (12%), and fuelwood collection (8%). The study further found that forest management was ineffective due to a lack of policy implementation, poor community participation, and weak law enforcement. The study closed a gap in the existing literature and added new knowledge to the scientific community. It recommends that the Zambian government implement a forestry policy to improve forest management.

Keywords: Land use and forest cover change; Dambwa; Local forest reserve; Settlement; Conversion; Joint Forest Management

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1. Introduction

Forests are among the most important natural resources for restoring ecosystems.[1] Therefore, forests have exceptional values for both human needs and environmental integrity.[2,3] Forests in Zambia cover about 66% of the total land area of the country, where about 9.6% is under protected forest reserve.[4,5] Dambwa Local Forest Reserve has experienced continued land use and forest cover change (LUFCC) since 1984 to date

due to various factors. For example, settlements have been expanding from the central business district of Livingstone town toward the forest reserve. By 1990, settlements had reached the edge of the reserve, exerting pressure on forest resources. The conversion of forests to other land uses is exacerbated by factors such as agricultural and settlement expansion, mining, logging, fuelwood production, and a weak legislative framework.[5-8]

Alves *et al.*[9] reported that, between 1985 and 2015, in the Western Brazilian Amazon of Rondônia state, deforestation and landscape fragmentation occurred due to settlement expansion. Meanwhile, urban sprawl and road networks were found to be accelerating factors for forest cover loss in the Amazon Forest.[10] Angelsen *et al.*[11] analyzed the economic drivers of deforestation and noted that poverty, a lack of alternative livelihoods, and weak property rights often compel communities to exploit forest resources unsustainably. Separate studies by Alemayehu *et al.*[12] and Gabisa *et al.*[13] in Ethiopia found that agricultural expansion, settlement expansion, charcoal production, firewood collection, and weak law enforcement are the main drivers of land use/land cover (LULC) change. Dembele *et al.*[14] conducted a spatiotemporal analysis of land cover change in the Bobiri Forest and its surrounding areas in Ghana's moist semi-deciduous forest zone, and their results indicated that the annual rates of land cover change were 1.64% between 1986 and 2007 and 1.04% between 2007 and 2022. In general, Dembele *et al.*'s results indicate that there was LULC change in their study area. Mgalula *et al.*[15] used Landsat images from 1996, 2006, and 2021 to quantify LULC change in the Mgori and Minyughe forest reserves of the Singida Region in central Tanzania. Their study found that cultivated land in the Mgori forest reserve increased by 33.56%, settlements by 32.67%, and bushland by 0.52%, while woodlands and grassland decreased by 0.60% and 0.22%, respectively.

In Zambia, some studies on LUFCC have been conducted elsewhere, apart from Dambwa Local Forest Reserve, and the results indicate general LUFCC. Zimba *et al.*[16] assessed land cover degradation using the integrated cellular automata–Markov model and the Trends Earth module, and their results indicated an average annual reduction rate of 0.13%. Banda[17] conducted remote sensing analysis and used a socioeconomic approach in his study, finding that forest cover changed by 0.065% per year between 1990 and 2005 in the Masese Local Forest Reserve in Sesheke District, Zambia, due to settlement expansion among other causes. Mutimba *et al.*[18] also carried out a study in Kitwe District, Zambia, using remote sensing analysis of Landsat Thematic Mapper (TM; 1990, 2000, and 2010) and Landsat 8 Operational Land Imager (OLI; 2020) images in Google Earth Engine with a random forest classifier to detect LULC changes. Their study found that 45.2% of the district area (360.92 km^2) experienced LULC changes from 1990 to 2020 due to mining activities. Integrated Land Use Assessment II of 2016 reported that settlement expansion, a driver of deforestation, increased by 0.48% from 137,245 ha in 2000 to 501,658 ha in 2014 in Zambia.[19] This is similar to what is happening at a global scale, where the global maps of forest loss depict the magnitude of forest disturbance.[20] The increasing population and growing demand for forest goods and services, as well as the demand for agricultural land and settlements,[21] have been identified as the main drivers of LUFCC, continuing to exert more pressure on forests.[22] According to the Government of the Republic of Zambia,[23] the proximate drivers of deforestation and forest degradation in Zambia are specific to its forestry, agriculture, energy, mining, and land use (infrastructure development) sectors. To effectively address these drivers, Zambia has developed the National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy, whose vision is to realize a prosperous, climate-change-resilient economy by 2030, anchored upon sustainable management and utilization of Zambia's natural resources toward improved livelihoods.[23]

The Zambia National REDD+ Strategy was developed after the 2014 National Forestry Policy, as one of the policy implementation efforts. Some of the strategic objectives of the National REDD+ Strategy are: (i) By 2030, threatened and unsustainably managed national and local forests are effectively managed and protected to reduce emissions from deforestation and forest degradation and contribute with ecosystem services across selected landscapes; (ii) By 2030, selected high value forests in open areas are effectively managed and monitored; (iii) By 2020, threatened and sensitive protected areas legislated as "no-go areas" for mining and infrastructure development; (iv) By 2025, land and resource rights on customary land legislated and secured; and (v) By 2020, relevant institutions capacitated to enable them to plan, manage, implement, and monitor REDD+ program activities.

It is worth noting that, despite Zambia having the National REDD+ Strategy, the National Forestry Policy, and other institutional frameworks in place, LUFCC has continued, as in other parts of the world.[24] For example, objective (iii), which emphasized that by 2020, threatened, sensitive protected areas would be legislated as "no-go areas" for mining and infrastructure developments, has not been implemented. Mining activities and infrastructure development are underway in some protected forest areas. The Zambia National REDD+ Strategy, together with the

Joint Forest Management (JFM) of 1999, could have helped reduce negative developments in forests and surrounding areas[25]; however, illegal expansion of settlements has continued. This is also a result of weak law enforcement. Scheba and Mustalahti[26] identified a similar problem in Tanzania, where policies and laws are not implemented. Therefore, strong law enforcement and full implementation of community resource management can help to reduce deforestation in affected areas in Zambia. The Zambia 2014 National Forestry Policy encourages participatory forest management anchored on the active participation of local communities, traditional institutions, the private sector, and other stakeholders in the management and utilization of forest resources at all levels of decision-making, implementation, monitoring, and evaluation.[4] If well implemented, the policy could have enhanced forest management and reduced forest loss in the country. As is the case in Congo, concessions approved under the Forestry Management Plan (FMP) and Forest Stewardship Council (FSC) certification, on a longer-term basis, led to lower deforestation than non-approved FMP concessions and FSC-certified concessions.[27] Deforestation can also be reduced by implementing a strong legal and institutional framework, ensuring financial sustainability, allowing participation of civil society groups, and securing political support at all levels.[28,29] The emphasis on the importance of institutional diversity and local participation in designing successful conservation policies is required in the management of forests. However, these legal frameworks must involve legal recognition of customary land rights,[23] implementation of land titling programs, and protection of communal or collective lands.[28] Despite having sound legal frameworks, institutional frameworks, and other interventions, forests have been facing threats of degradation worldwide, Zambia inclusive, due to several factors outlined above.

While significant studies have been conducted by various researchers worldwide and in Zambia, the status of Dambwa Local Forest Reserve remains unknown. Therefore, there is a need for additional empirical studies to assess LUFCC, identify its drivers, and evaluate the effectiveness of participatory forestry management in Dambwa Local Forest Reserve between 1984 and 2024 to fill the existing gap.

2. Materials and methods

2.1. Study area

This study was conducted in Dambwa Local Forest Reserve, Livingstone District, Southern Province, Zambia (Figure 1). Dambwa Local Forest Reserve is located in the Barotse sub-basin, which is a component of the Zambezi Catchment area. The area of Dambwa Local Forest Reserve is 14,930 ha. The geographical coordinates of the area have minimum and maximum latitudes of −17.736267° and −17.735186°, respectively, while the minimum and maximum longitudes are 25.801754° and 25.805469°, respectively.

2.2. Research design

The research involved a spatiotemporal, quantitative, qualitative, and field observation approach that applied mixed methods to assess LUFCC, identify its drivers, and evaluate the effectiveness of participatory forestry management in Dambwa Local Forest Reserve between 1984 to 2024.[30] Land use change detection and analysis were performed based on Landsat 5 TM and Landsat 8 OLI/Thermal Infrared Sensor (TIRS) imagery between 1984 and 2024. Land cover classification was used to detect forest cover change (increases or decreases). LUFCC classes were generated into maps for each year. Furthermore, ground-truthing data of 38 sites (Figure 2) were collected using a global positioning system (GPS).

2.3. Imagery data collection

Remote sensing data were accessed from the United States (US) Geological Survey website (https://earthexplorer.usgs.gov). The main sources of remote sensing data were Landsat 5 TM bands 3, 4, 5, and 7, and Landsat 8 OLI/TIRS bands 4, 5, 6, and 7. The data were accessed and analyzed over 10-year time periods starting in 1984, 1994, 2004, 2014, and 2024.

2.4. Imagery data analysis

Classification was performed in QGIS 3.26.3 using the maximum likelihood classification algorithm and training areas for each class. The selected bands and regions of interest (ROIs) for each year were used for classification. The maximum likelihood classification algorithm was then applied to the ROIs. Each primary observation was classified into one of the six classes as follows: grassland, forest, bare land, settlement, water bodies, and cropland).

2.5. Accuracy assessment

The accuracy of the land cover classification was assessed using a confusion matrix and ground-truth points with the ROI tool in the post-classification module in QGIS 3.26.3. The confusion matrix was generated from ground-truth data. A total of 38 ground-truthing points per class were generated using the stratified method in QGIS 3.26.3. The shapefile of the generated ground-truth points was converted to a compatible KLM format file for use in Trimble Juno 3D GPS (Trimble Inc., US) and Google Earth (Google, US). Land cover classification maps were

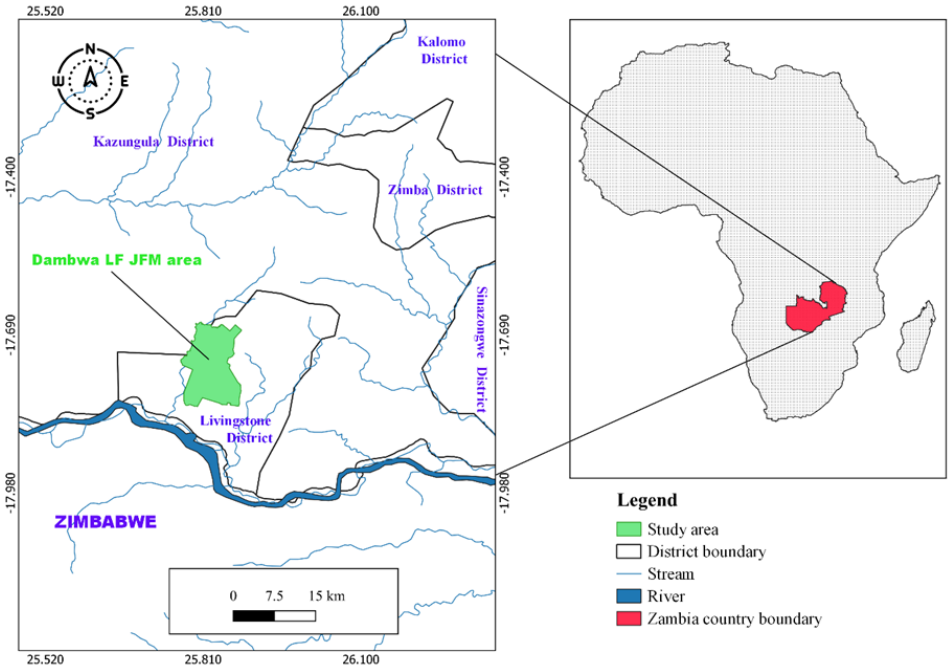


Figure 1. Map showing the location of Dambwa Local Forest (LF) Reserve in Livingstone, Zambia
Abbreviation: JFM: Joint Forest Management.

validated using ground-truth points. A hybrid method of obtaining ground-truth data was used, and Google Earth-based data were combined to validate the classification.

2.6. Quantitative and qualitative data collection

In this study, the primary methods of data collection included an interview schedule, key informant interviews, and focus group discussions, all conducted using purposive sampling. For the interview schedule, 180 heads of households living on the margins of Dambwa Local Forest Reserve were interviewed. The key informant interviews included district officials (district commissioners, forestry, agriculture, education, health, fisheries, and chiefs), traditional leadership, ward development committees, the private sector, nongovernmental organizations, and civil society organizations. The focus group discussion was conducted with ward development committee members and section committee members.

2.7. Field data analysis

Descriptive statistics of percentages were used to analyze quantitative data collected in the field, which were entered into Microsoft Excel. The results were presented using graphical presentations involving bar graphs and tables for categorical data. The qualitative data were analyzed using the Hyper research tool to identify patterns and trends in the data collected from key informants and focus group discussions. Data were summarized through data reduction. This involved coding themes according to the research questions and categorizing similar coded themes into groups.

3. Results and discussion

3.1. Extent of land cover changes in Dambwa Local Forest Reserve

Forest cover change has alternated between gains and losses (Figure 3). The average change over the 40 years was 8.7%, with an annual rate of 0.22%. In 1984, Dambwa Local Forest Reserve had 68.88% forested area, which slightly increased to 68.93% in 1994. In 2004, it decreased to 75.60%, then rose slightly by 3.23 percentage points to 78.83%, and later sharply decreased to 60.18% (18.65 percentage-point reduction). This change is also associated with the conversion of 420.95 ha (4.2095 km^2) of forest to settlement, among other causal factors. Mutimba *et al.*[18] also reported that 45.2% of the Kitwe District area experienced LULC changes from 1990 to 2020 due to mining activities. Considering that Zambia has a sound forestry policy[4] and National REDD+ Strategy,[23] the forest was expected to record gains rather than losses. Both national documents guide that threatened and sensitive protected areas must

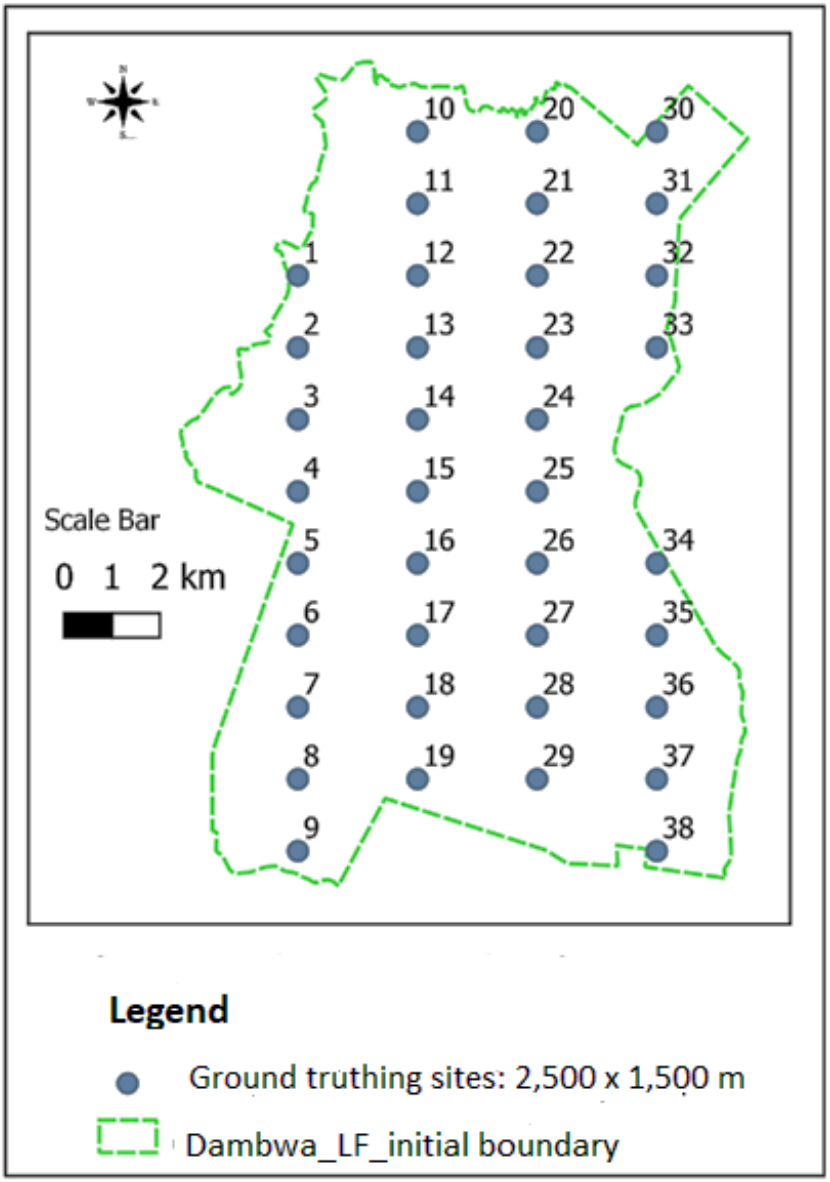


Figure 2. Ground-truthing sample sites map in Dambwa Local Forest Reserve

be legislated as "no-go areas" for mining and infrastructure development. However, the reality is the opposite: there are many counteractivities taking place in many forest reserves in Zambia.

Dambwa Local Forest Reserve has seen a conversion of 420.95 ha (4.2095 km^2), with the remaining 1589.05 ha (15.8905 km^2) to be converted gradually as demand from individuals, organizations, private enterprises, and state agencies continues to increase for construction projects. Gowri *et al.*[31] found that vegetation in the Yellapur forest division, Uttara Kannada district, India, which covered 178,108 ha (90.35%) in 2000, decreased to 160,018 ha (81.68%) by 2023, an 8.67 percentage-point reduction due to deforestation, agricultural expansion, and infrastructure development.

3.2. Land use and forest cover changes by class between 1984 and 2024

The LUFCCs were observed in four classes: forest, settlement, grassland, and cropland (Figure 4 and Table 1). In 1984, the forest class was 68.88%, decreasing to 60.18%

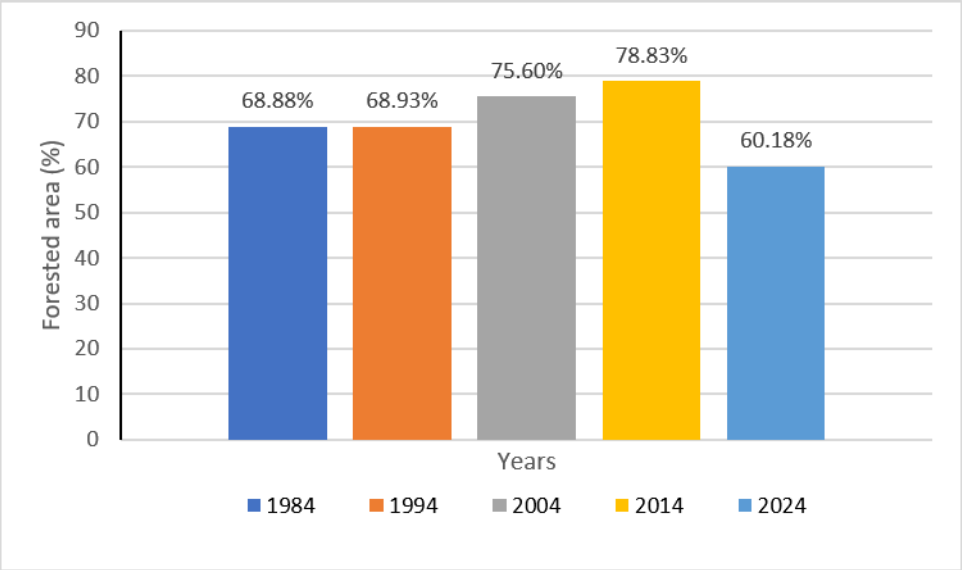


Figure 3. Forest cover changes from 1984 to 2024

in 2024. The settlement class increased from 0% to 8.03%, the grassland class increased from 19.9% to 31.63%, and the cropland class decreased from 11.22% to 0.16% over the same period. During the same period, the water bodies class remained at 0%. While some forests in other countries are recording significant increases in forested area, forests in Zambia are recording losses.[32] The findings of Banda[17] attest to this, as his study found that there was a forest cover change of a 0.065% decrease per year between 1990 and 2005 in Masese Local Forest Reserve in Sesheke District, Zambia, due to factors such as settlement expansion. However, it is important to note that LUFCC in Dambwa Local Forest Reserve is higher (0.22%) than that of Masese Local Forest Reserve (0.065%),[17] a situation which should not be left unresolved. Our study's findings are contrary to previous findings,[32,33] which showed a noticeable increase in both closed forest and open forest areas, with a decrease in grasslands in El Rawashda Forest, Sudan, where more than one third of grassland (36%) was converted to closed forest and one-fourth (24%) to open forest areas.

A total of 38 sample plots were generated across the study area, of which 18.42% fell in settled areas. This kind of representation was only prevalent in the last 10 years of the 40-year period. The changes in classes have environmental implications for forest cover. Krishnan *et al.*[34] found that LULC and climate variability can lead to forest cover change. The forest has been gradually opening up from the south to the north. This has been observed across the years covered by the study period. Forest degradation in Dambwa Local Forest Reserve is occurring intensively in forested areas close to settlements due to activities such as harvesting wild food, medicinal plants, fuelwood, and timber, which are central to people's livelihoods. Therefore, forest degradation in the study area will in turn adversely affect local people's livelihoods. This finding is similar to those of Banda,[17] Khan *et al.*,[35] and Kihia *et al.*,[36] who found that local people's livelihoods were affected by forest cover change in their respective studies, due to limited adaptation options from forests.

3.3. Key factors driving land use and forest cover change in Dambwa Local Forest Reserve

This study identified various factors responsible for LUFCC in Dambwa Local Forest Reserve: settlement, infrastructure development, population growth, agriculture, and fuelwood collection. The respondents alluded to settlement establishment (45%) as a major driving factor. These settlements include both legal (where 420.95 ha [4.2095 km^2] of forest land were converted to settlement) and illegal (encroachment) settlements. Population growth (25% of respondents) was identified as another leading driver. There is a high influx of people from rural areas and other towns across the country seeking land for settlement. This finding is similar to that of Handavu *et al.*,[37] who found that population growth and immigration are among the most influential drivers of LULC changes. Infrastructure development (20% of respondents) ranked third among drivers of LUFCC in the study area. This involves developing business establishments such as hotels, lodges, and shopping malls. Livingstone is a tourist hub in Zambia, and demand for tourism-related infrastructure, such as hotels and lodges,

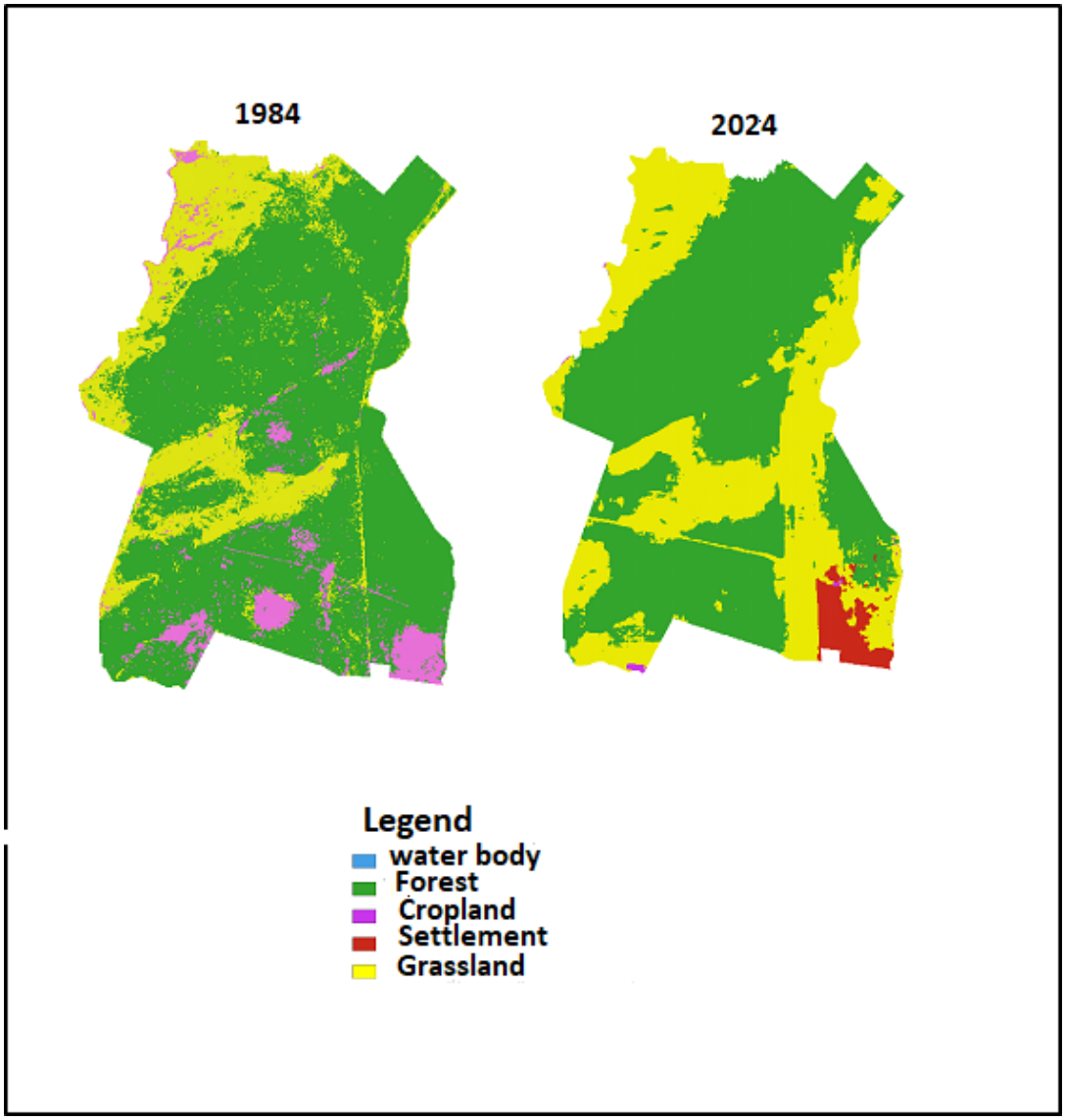


Figure 4. Land use and forest cover change in Dambwa Local Forest Reserve, Livingstone, Zambia

Table 1. Forest classes inventory in Dambwa Local Forest Reserve, Livingstone, Zambia (1984 and 2024)

Class	Status in 1984 (%)	Status in 2024 (%)	Remarks
Forest	68.88	60.18	Dominant class showing a reduction in size
Grassland	19.90	31.63	The class tended toward an increase in size
Settlement	0	8.03	The class tended toward an increase in size
Water body	0	0	The class was not represented in sample plots
Cropland	11.22	0.16	Cropland data were administered for gardens and maize fields

is very high. Consequently, the local authority is forced to request the degazetting of portions of the forest for other land uses, so that it can allocate land for the construction of such facilities within the forest and on its margins. Agriculture (12% of respondents) ranked fourth among causes of LUFCC in the study area. Some people who migrate to Livingstone have no source of livelihood and resort to illegal forest clearing to cultivate land for their crops. On the other hand, fuelwood collection (8% of respondents) was the least important driver of LUFCC. With electricity shortages in the district compounded by high poverty levels, local people indiscriminately cut trees in the forest to supply energy for their homes.

3.4. Effectiveness of participatory forestry management in Dambwa Local Forest Reserve

The findings from key informant interviews and focus group discussions indicate that forest management in Dambwa Local Forest Reserve was ineffective. The key factors alluded to were the lack of policy implementation, the lack of community participation, and weak law enforcement. Despite Zambia having a National Forestry Policy and a National REDD+ Strategy,[4,23] implementation remains ineffective. As a result, LUFCCs in most forest reserves have increased, including Dambwa Local Forest Reserve. There is also poor participation by the community and other stakeholders. If the community and other stakeholders are not involved, they will not regard the forest resources as theirs. Consequently, they will tend to overexploit the resources, leading to the tragedy of the commons. Restoration initiatives, which often require effective management facilitated through participatory approaches such as JFM, were found to be poor due to ineffective management. The Department of Forestry was understaffed, with only 12 staff members. On the other hand, JFM (though ineffective) had more members, with a minimum of 102 key members, including 12 government staff, 80 elected community representatives, and 8 members from participating villages. The JFM could have helped manage the forest if it had been fully operational with clear guidelines. This can work well with the involvement of private corporations.[38] Therefore, the approach of involving local communities and stakeholders can improve management, as most emerging threats can be reduced. This is consistent with other studies on JFM[39] that found it effective due to clear guidelines and relevant government support. Community involvement often leads to more sustainable land use, as confirmed by research findings in Ghana[40] and Tanzania,[41] which observed that forest restoration associated with higher levels of local community responsibility for protecting forests in their vicinity yields greater dividends. Chervier *et al.*[42] found that forest management units play a major role in reducing forest loss and forest fires in Sulawesi.

3.5. Limitations and recommendations

The Landsat images for 1994, 2004, and 2014 had cloud cover exceeding 10%. Consequently, the processed images were unclear and could not be presented. Images used for LULC classification are generally required to have cloud cover of 10% or less. Nevertheless, the LULC classification statistics obtained from these images were considered accurate.

The study recommends that the Zambian government enforce the National Forestry Policy and the National REDD+ Strategy to improve forest reserve management.

4. Conclusion

The study found that LUFCCs have been alternating between gains and losses. The average change across the 40 years was 8.7% with an annual rate of 0.22%. The change per class was forest (60.18%), settlement (8.03%), grassland (31.63%), and cropland (0.16%). The identified driving factors were settlement (45%), population growth (25%), infrastructure development (20%), agriculture (12%), and fuelwood collection (8%). The study found ineffective forest management in Dambwa Local Forest Reserve due to the lack of policy implementation, limited community participation, and weak law enforcement. Therefore, Dambwa Local Forest Reserve has experienced increased and ongoing LUFCC.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Arnold Mahonko Banda, Chilala Chooma
Formal analysis: Arnold Mahonko Banda
Investigation: Chilala Chooma
Methodology: Arnold Mahonko Banda, Chilala Chooma
Writing–original draft: Arnold Mahonko Banda, Chilala Chooma
Writing–review & editing: Arnold Mahonko Banda

Ethics approval and consent to participate

Consent to participate and permission to collect data were obtained from participants.

Consent for publication

Authors obtained consent from participants to publish their data.

Availability of data

The data are available from the corresponding author upon reasonable request.

AI tools statement

None.

References

1. Watson JE, Evans T, Venter O, *et al.* The exceptional value of intact forest ecosystems. *Nat Ecol Evol.* 2018;2(4):599-610.

   doi: 10.1038/s41559-018-0490-x

2. Edwards DP, Tobias JA, Sheil D, Meijaard E, Laurance WF. Maintaining ecosystem function and services in logged tropical forests. *Trends Ecol Evol*. 2014;29(9):511-520.

   doi: 10.1016/j.tree.2014.07.003

3. Filho WL, Azul AM, Brandli L, Salvia AL, Wall T, eds. *Life on Land*. Springer; 2021.

   doi: 10.1007/978-3-319-95981-8

4. Government of the Republic of Zambia. National Forestry Policy. Ministry of Lands, Natural Resources and Environmental Protection, Forestry Department; 2014.

5. Food and Agriculture Organization. Global Forest Resources Assessment: Main Report. FAO; 2020.

   doi: 10.4060/ca9825en

6. Curtis PG, Slay CM, Harris NL, Tyukavina A, Hansen MC. Classifying drivers of global forest loss. *Science*. 2018;361(6407):1108-1111.

   doi: 10.1126/science.aau3445

7. Rosa IMD, Souza C, Ewers RM, Gardner TA. Spatial and temporal distribution of illegal logging in the Brazilian Amazon. *Reg Environ Change*. 2017;17(6):1687-1699.

   doi: 10.1007/s10113-017-1120-x

8. Colman CB, Guerra A, Almagro A, *et al.* Modeling the Brazilian Cerrado land use change highlights the need to account for private property sizes for biodiversity conservation. *Sci Rep*. 2024;14:4559.

   doi: 10.1038/s41598-024-55207-1

9. Alves MTR, Piontekowski VJ, Buscardo E, Pedlowski MA, Sano EE, Matricardi EAT. Effects of settlement designs on deforestation and fragmentation in the Brazilian Amazon. *Land Use Policy*. 2021;109:105710.

   doi: 10.1016/j.landusepol.2021.105710

10. Taubert F, Fischer R, Groeneveld J, *et al.* Global patterns of tropical forest fragmentation. *Nature*. 2018;554(7693):519-522.

    doi: 10.1038/nature25508

11. Angelsen A, Martius CV, de Sy V, Duchelle AE, Larson AM, Pham TT, eds. *Transforming REDD+: Lessons and New Directions*. Center for International Forestry Research; 2018.

    doi: 10.17528/cifor/007045

12. Alemayehu A, Abdeta D, Ababu T, *et al.* Perceptions of drivers of land use and land cover change from forest to agriculture in Ethiopia. *Landsc Ecol*. 2025;40(11).

    doi: 10.1007/s10980-025-02216-8

13. Gabisa M, Gizachew K, Siraj M. Land use and land cover change trends, drivers and its impacts on ecosystem services in Burayu sub city, Ethiopia. *Front Environ Sci*. 2025;13:1557000.

    doi: 10.3389/fenvs.2025.1557000

14. Dembele F, Guuroh RT, Ansah PB, Asare DCBM, Biney E, Adu-Bredu S. Drivers of land use land cover change and intensity analysis of land transformation in the moist semi-deciduous forest zone of Ghana: Case of Bobiri Forest Reserve and its environs. *Agrocienc Urug.* 2023;27(NE2):e1244.

    doi: 10.31285/AGRO.27.1244

15. Mgalula ME, Majule AE, Saria AE, Mwakisunga B. Land use and land cover changes and their driving forces in selected forest reserves in Central Tanzania. *Trees For People*. 2024;16:100584.

    doi: 10.1016/j.tfp.2024.100584

16. Zimba HM, Banda KE, Mbewe S, Nyambe I. Integrated use of the CA–Markov model and the Trends.Earth module to enhance the assessment of land cover degradation. *Environ Syst Res*. 2024;13(1):25.

    doi: 10.1186/s40068-024-00355-6

17. Banda AM. *Forest cover change and its effects on the livelihoods of the dependent local communities in Masese Local Forest Reserve in Sesheke District*. Master's thesis. University of Zambia; 2016. Accessed September 10, 2024. https://dspace.unza.zm/items/778b8a3e-4f35-4e2f-9d95-3fccb453da6c

18. Mutimba K, Watanabe T, Chand MB. Land Use Land Cover (LULC) Change Dynamics Associated with Mining Activities in Kitwe District and Adequacy of the Legal Framework on Mine Closure in Zambia. *Earth*. 2024;5(2):110-132.

    doi: 10.3390/earth5020006

19. Integrated Land Use Assessment Phase II. *Integrated Land Use Assessment Phase II Report*. Forestry Department,

Ministry of Lands and Natural Resources; 2016.

20. Voigt M, Supriatna J, Deere NJ, *et al.* Emerging threats from deforestation and forest fragmentation in the Wallacea centre of endemism. *Environ Res Lett*. 2021;16(9):094048.

doi: 10.1088/1748-9326/ac15cd

21. Barbier EB, Burgess JC. The economics of tropical deforestation. *J Econ Surv*. 2001;15(3):413-433.

doi: 10.1111/1467-6419.00144

22. Newbold T, Hudson LN, Arnell AP, *et al.* Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science*. 2016;353(6296):288-291.

doi: 10.1126/science.aaf2201

23. Government of the Republic of Zambia. Zambia National Strategy to Reduce Emissions from Deforestation and Forest Degradation (REDD+). Forestry Department; 2015.

24. Nagaraja BC, Maskey N, Somashekara RK. Regeneration of native woody species under plantations in Kudremukh National Park, Western Ghats of South India. *Int J Biodivers Sci Ecosyst Serv Manag*. 2011;7(2):77-83.

doi: 10.1080/21513732.2011.622297

25. Phiri M. *Evaluation of the Performance of Joint Forest Management (JFM) Programme: Case of Dambwa Forest Reserve in Livingstone District, Zambia*. Master's thesis. Stellenbosch University; 2009.

26. Scheba A, Mustalahti I. Rethinking 'expert' knowledge in community forest management in Tanzania. *For Policy Econ*. 2015;60:7-18.

doi: 10.1016/j.forpol.2014.12.007

27. Tritsch I, Le Velly G, Mertens B, *et al.* Do forest-management plans and FSC certification help avoid deforestation in the Congo Basin? *Ecol Econ*. 2020;175:106660.

doi: 10.1016/j.ecolecon.2020.106660

28. Sarmiento F, Larrea C, Oeschger A, Jose R. *Measures to Enhance Forest Conservation and Reduce Deforestation: Viewpoints and Lessons from Producing Countries*. International Institute for Sustainable Development; 2024. Accessed September 10, 2024. https://www.iisd.org/publications/report/ssi-measures-enhance-forest-conservation-reduce-deforestation

29. Chomba S, Kariuki J, Lund JF, Sinclair F. Roots of inequity: How the implementation of REDD+ reinforces past injustices. *Land Use Policy*. 2016;50:202-213.

doi: 10.1016/j.landusepol.2015.09.021

30. Kumar R. *Research Methodology: A Step-by-Step Guide for Beginners*. 3rd ed. SAGE Publications; 2011.

31. Gowri BG, Koppad AG, Amarnath AT, *et al.* Assessment of spatial and temporal change in the Yellapur forest division, Uttara Kannada district, Karnataka, using a remote sensing approach. *Int J Res Agron*. 2024;7(9):946-954.

doi: 10.33545/2618060X.2024.v7.i9Sm.1637

32. Sujathaa N. Change detection matrix in land use and land cover classification using GIS. *IJRASET*. 2020;8(10):577-582.

doi: 10.22214/ijraset.2020.31957

33. Ankomah F, Kyereh B, Ansong M, Asante W. Forest management regimes and drivers of forest cover loss in forest reserves in the High Forest Zone of Ghana. *Int J For Res*. 2020;2020:8865936.

doi: 10.1155/2020/8865936

34. Krishnan G, Ramasamy J. An assessment of land use and land cover changes in Muthupet Mangrove Forest, using time series analysis 1975-2015, Tamilnadu, India. *Geosfera Indones*. 2022;7(2):119-135.

doi: 10.19184/geosi.v7i2.28077

35. Khan N, Fahad S, Naushad M, Faisal S. Analysis of livelihood in the world and its impact on world economy. *SSRN*. 2020.

doi: 10.2139/ssrn.3717265

36. Kihia CM, Mathooko JM, Ruwa RK, Shivoga WA. Influence of human disturbance on patterns of leaf herbivory at Gazi Bay mangrove forest, Kenya. *Afr J Aqua Ecol*. 2011;36(3):235-241.

doi: 10.2989/16085914.2011.636901

37. Handavu F, Chirwa PWC, Syampungani S. Socio-economic factors influencing land-use and land-cover changes in the miombo woodlands of the Copperbelt province in Zambia. *For Policy Econ.* 2019;100:75-94.

doi: 10.1016/j.forpol.2018.10.010

38. Poudyal M, Ramamonjisoa BS, Hockley N, *et al.* Can REDD+ social safeguards reach the 'right' people? Lessons from Madagascar. *Glob Environ Change*. 2016;37:31-42.

doi: 10.1016/j.gloenvcha.2016.01.004

39. Khalid W, Shamim SK, Alam Mohd, *et al.* Coupled analysis of hydroclimatic variability, land use land cover change, and socio-economic adaptation in Uttarakhand using integrated remote sensing and GIS techniques. *Sustain Geosci People Planet Prosper.* 2026;2:100018.

doi: 10.1016/j.susgeo.2026.100018

40. Arts B, Buizer M, Horlings L, Ingram V, van Oosten C, Opdam P. Landscape approaches: A state-of-the-art review. *Annu Rev Environ Resour.* 2017;42:439-463.

doi: 10.1146/annurev-environ-102016-060932

41. Center for Bioethics. A Guide to Research Ethics. University of Minnesota; 2003. Accessed August 15, 2022. https://www.ahc.umn.edu/img/assets/26104/Research_Ethics.pdf

42. Chervier C, Atmadja SS, Nofyanza S, *et al.* Impact of

Indonesia's Forest Management Units on the reduction of forest loss and forest fires in Sulawesi. *Ecol Econ*. 2025;227:108418.

doi: 10.1016/j.ecolecon.2024.108418