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Assessment of Land Degradation in Agricultural Systems of Chipipa Commune, Huambo Province (Angola)

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A B S T R A C T

Land degradation represents a major environmental challenge in regions dependent on smallholder agriculture, directly affecting agricultural productivity and rural livelihoods. This study aimed to assess the extent and spatial patterns of land degradation in the Chipipa commune, Huambo Province, Angola, using the FAO-LADA methodology. The research adopted an integrated approach, combining geospatial analysis, soil and vegetation biophysical indicators, and socioeconomic instruments. The spatial assessment was based on the indicators of Sustainable Development Goal 15.3.1 (SDG 15.3.1), while soil and vegetation conditions were evaluated through Visual Soil Assessment (VSA) and linear transects. Socioeconomic data were collected through semi-structured interviews with land users, household representatives, and key informants. The results revealed a heterogeneous spatial distribution of land degradation, with critical areas associated with reduced land productivity. Soil compaction and erosion were identified as the main degradation processes, particularly in land uses with limited vegetation cover. Vegetation structure was simplified in agricultural and pasture areas, whereas forested and riparian zones exhibited better conservation conditions. Socioeconomic results indicated high community vulnerability, characterized by subsistence-oriented farming systems and limited adoption of sustainable land management practices. Overall, land degradation in the study area results from the interaction between biophysical and socioeconomic factors, and the FAO-LADA methodology proved effective in supporting the identification of priority areas and the planning of sustainable land management strategies.

Keywords: Land degradation, FAO-LADA, Biophysical indicators, Smallholder agriculture.

Avaliação da Degradação do Solo em Sistemas Agrícolas da Comuna da Chipipa, Província do Huambo (Angola)

R E S U M O

A degradação de terras constitui um dos principais desafios ambientais em regiões dependentes da agricultura familiar, comprometendo a produtividade agrícola e os meios de subsistência rurais. Neste contexto, o presente estudo teve como objetivo avaliar a extensão e os padrões da degradação de terras na comuna da Chipipa, província do Huambo, Angola, utilizando a metodologia FAO-LADA. A pesquisa adotou uma abordagem integrada, combinando análise geoespacial, indicadores biofísicos do solo e da vegetação e instrumentos socioeconómicos. A avaliação espacial baseou-se nos Indicadores dos Objetivos de Desenvolvimento Sustentável 15.3.1 (ODS 15.3.1), enquanto os indicadores biofísicos foram obtidos por meio de Avaliação Visual do Solo (VSA) e de transectos lineares para a vegetação. Os dados socioeconómicos foram recolhidos por meio de entrevistas semiestruturadas aplicadas a utilizadores da terra, a agregados familiares e a informadores-chave. Os resultados evidenciaram padrões espaciais heterogéneos de degradação, com predominância de zonas críticas associadas à redução da produtividade da terra. A compactação e a erosão destacaram-se como os principais processos de degradação do solo, sobretudo em usos com menor cobertura vegetal. A vegetação apresentou estrutura simplificada em áreas agrícolas e de pastagem, enquanto áreas florestais e zonas ripícolas revelaram melhores condições de conservação. A avaliação socioeconómica indicou elevada vulnerabilidade das comunidades, caracterizada pela predominância da agricultura de subsistência e limitada adoção de práticas conservacionistas. Conclui-se que a degradação de terras na área de estudo resulta da interação entre fatores biofísicos e socioeconómicos, sendo a metodologia FAO-LADA uma ferramenta eficaz para apoiar o planeamento de estratégias de Gestão Sustentável de Terras.

Palavras-chave: Degradação de terras, FAO-LADA, Indicadores biofísicos, Agricultura familiar.

Evaluación de la Degradación del Suelo en Sistemas Agrícolas de la Comuna de Chipipa, Provincia de Huambo (Angola)

R E S U M E N

La degradación de tierras constituye uno de los principales desafíos ambientales en regiones dependientes de la agricultura familiar, afectando la productividad agrícola y los medios de vida rurales. El presente estudio tuvo como objetivo evaluar la extensión y los patrones de la degradación de tierras en la comuna de Chipipa, provincia de Huambo, Angola, utilizando la metodología FAO-LADA. Se adoptó un enfoque integrado que combinó análisis geoespacial, indicadores biofísicos del suelo y de la vegetación, y herramientas socioeconómicas. La evaluación espacial se basó en los indicadores del Objetivo de Desarrollo Sostenible 15.3.1 (ODS 15.3.1), mientras que las condiciones del suelo y la vegetación se analizaron mediante Evaluación Visual del Suelo (VSA) y transectos lineales. Los datos socioeconómicos se obtuvieron a través de entrevistas semiestructuradas con usuarios de la tierra, representantes de hogares e informantes clave. Los resultados mostraron una distribución espacial heterogénea de la degradación, con áreas críticas asociadas a la disminución de la productividad de la tierra. La compactación y la erosión fueron los principales procesos de degradación del suelo, especialmente en usos con menor cobertura vegetal. La vegetación presentó una estructura simplificada en áreas agrícolas y de pastoreo, mientras que las zonas forestales y ribereñas mostraron mejores condiciones de conservación. Se concluye que la degradación de tierras resulta de la interacción entre factores biofísicos y socioeconómicos, y que la metodología FAO-LADA es una herramienta eficaz para apoyar la gestión sostenible de la tierra.

Palabras clave: Degradación de tierras, FAO-LADA, Indicadores biofísicos, Agricultura familiar.

1. Introduction

Land degradation represents one of the most pressing contemporary environmental challenges, with direct impacts on ecosystem services, agricultural productivity, and human livelihoods. It is estimated that this phenomenon affects at least 3.2 billion people worldwide, being closely associated with food insecurity, rural poverty, and the intensification of global climate change (Costanza, De Groot, et al., 2014; Shukla et al., 2019). Economic losses resulting from the degradation of terrestrial ecosystems are also significant, ranging between USD 4.3 and 20.2 billion annually, highlighting the magnitude of this problem at the global scale. (Costanza, De Groot, et al., 2014).

Land, understood as the integration of soil, water, and biodiversity, plays a central role in the sustainability of socio-ecological systems. Soil represents an essential resource for food production, regulation of the hydrological cycle, and nutrient cycling. However, it is highly vulnerable to degradation processes such as erosion, compaction, loss of organic matter, and decline in biological activity (Kabato et al., 2025). These processes largely result from the interaction between natural factors and anthropogenic activities, including unsustainable agricultural practices, deforestation, recurrent burning, and inappropriate land use (Prăvălie et al., 2020).

Within the African context, and particularly in Angola, land degradation poses a growing threat to food security and the sustainable development of rural communities. Despite the country's recognized agricultural potential, the extent and specific impacts of land degradation remain insufficiently assessed, particularly in the current post-conflict context (Constantino, 2019a). Land degradation poses a growing threat to food security and the sustainable development of rural communities. Despite the country's recognized agricultural potential, the extent and specific impacts of land degradation remain insufficiently assessed, particularly in the current post-conflict context.

Huambo province is an agriculturally important region located in Angola's central plateau, where soil degradation processes have been intensified by unsustainable agricultural practices, deforestation, and water erosion. These processes have resulted in declining agricultural productivity and progressive impoverishment of rural communities. Several regions of the country have been identified as land degradation hotspots, associated with extensive agriculture, overgrazing, burning practices, and limited institutional capacity for environmental management (Constantino, 2019a).

Given the complexity and multidimensional nature of land degradation, the adoption of robust and integrated methodologies is essential for systematically evaluating the biophysical and socioeconomic drivers associated with this phenomenon. In this context, the *Land Degradation Assessment in Drylands* (LADA) methodology, developed by the Food and Agriculture Organization of the United Nations (FAO), stands out for its holistic approach, integrating field data, biophysical indicators, socioeconomic information, and geospatial analysis tools to assess land degradation.

The integration of field observations with geospatial data and remote sensing techniques enables a comprehensive and evidence-based assessment capable of supporting decision-making processes and environmental policy design (Ghosh et al., 2024).

The application of the FAO-LADA methodology in the Chipipa commune, Huambo Province, is particularly relevant given the strategic importance of this region for agricultural production and the increasing pressure on local natural resources. Furthermore, linking land degradation assessment with the promotion of agroecological practices represents a promising approach to reversing degradation trends, promoting biodiversity conservation, and strengthening agroecosystem resilience, thereby contributing to the environmental and socioeconomic sustainability of rural communities (Nicholls et al., 2004; Paracchini et al., 2020).

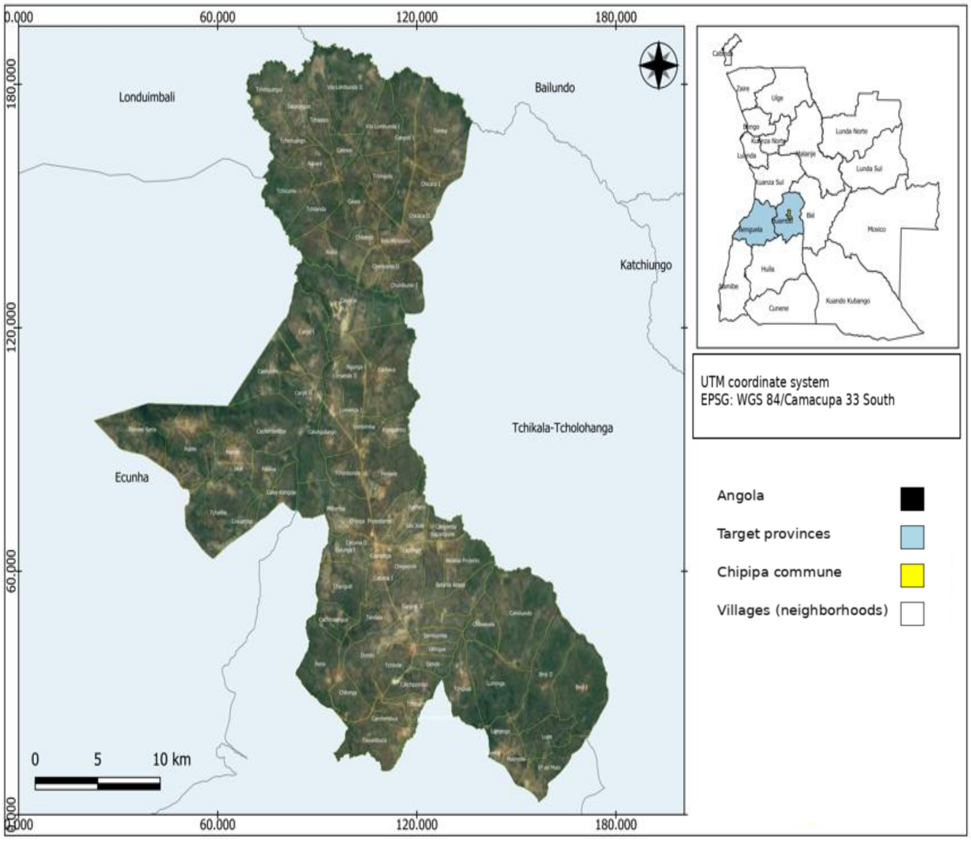
Therefore, the present study aims to investigate the extent and spatial patterns of land degradation in the Chipipa commune, Huambo Province, using the FAO-LADA methodology to support the development of sustainable land management strategies. Specifically, the study seeks to assess the biophysical factors associated with land degradation, with emphasis on soil and vegetation parameters, identify the main local drivers contributing to soil degradation, and propose agroecological practices aimed at reversing degradation processes and promoting environmental sustainability in the study area.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Chipipa commune, located in Huambo Province, in the central plateau region of Angola. This region is characterized by a high dependence on smallholder agriculture and increasing pressure on natural resources (FAO, 2023) (Figure 1).

Figure 1 – Geographic location map of the Chipipa commune
Figura 1 – Mapa de enquadramento geográfico da comuna da Chipipa



Source: Authors (2025).
Fonte: Autores (2025).

Two administrative sectors, Ngunga and Lomanda 2, were selected as representative areas due to their different land-use patterns and levels of land degradation, based on preliminary analysis of geospatial data and local information

2.2 Research Design and Methodological Approach

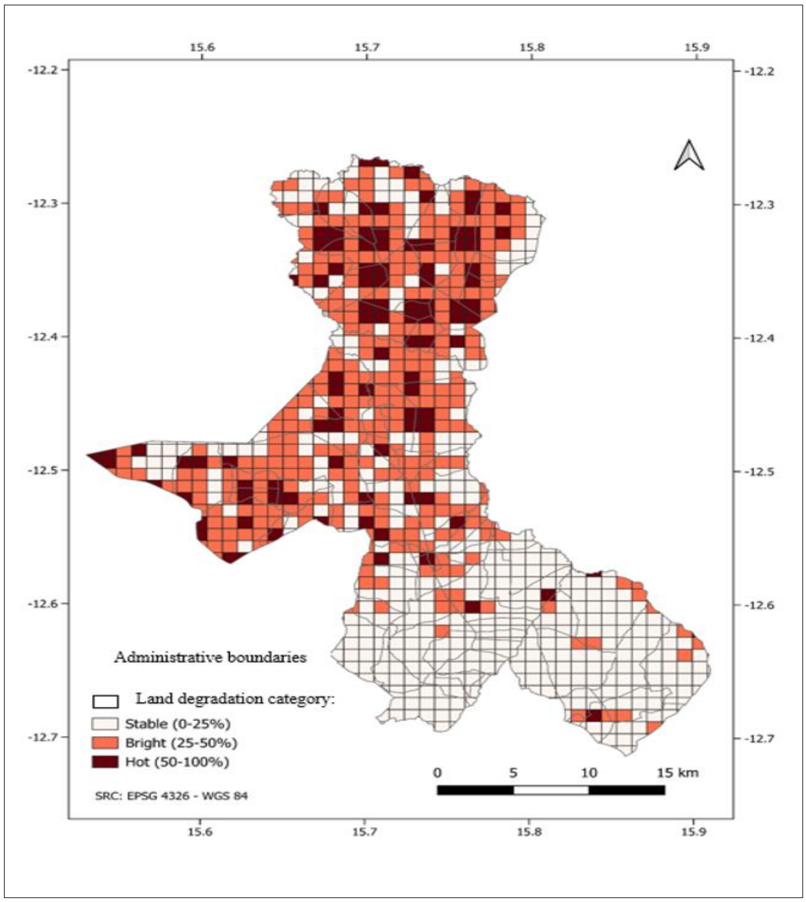
The research adopted a descriptive and exploratory design, using an integrated approach that combined field observations, analysis of biophysical indicators, and participatory tools. The assessment of land degradation was based on the *Land Degradation Assessment in Drylands* (LADA) methodology developed by the Food and Agriculture Organization of the United Nations (FAO), recognized for its holistic approach in analyzing land degradation processes and sustainable land management.

2.3 Site Selection and Fieldwork

Sampling areas were selected through geospatial data analysis within a Geographic Information System (GIS) environment, using the SEPAL platform, supported by SDG 15.3.1 indicators.

The sectors were stratified into 100 × 100 m grid cells and classified into the categories *Stable* (0–25%), *Bright* (25–50%), and *Hot* (50–100%), according to the percentage of degraded areas within each cell (Figure 2).

Figure 2. Stratification of the Chipipa commune according to the percentage of land degradation.
Figura 2 - Estratificação da comuna da Chipipa de acordo a percentagem de degradação



Source: Authors (2026).
Fonte: Autores (2026).

From the 113 sectors identified in the Chipipa commune, 15 were pre-selected and 13 were visited during fieldwork, resulting in the validation of the Ngunga and Lomanda 2 sectors for detailed analysis. Fieldwork included the establishment of linear transects and systematic landscape recording through direct observations and photographic documentation.

Fieldwork included the establishment of linear transects, systematic landscape observations, and photographic documentation.

2.4 Biophysical Assessment of Soil and Vegetation

The biophysical assessment of soil was based on visual and observational indicators. Soil properties were evaluated using the *VS-Fast Soil Visual Assessment method*, described in the LADA-FAO framework and complemented by the *Rapid, Farmer-Friendly Agroecological Method (RFFAM)* proposed by (Nicholls et al., 2004). The evaluation considered several soil parameters, including soil erosion, soil compaction, soil structure, effective soil depth, surface cover, and biological activity.

A semi-quantitative classification was applied to assess the intensity of erosion processes, assigning scores ranging from 1 to 10 according to the observed attributes, where 1 represented the least desirable condition, 5 indicated a moderate condition, and 10 corresponded to the most desirable condition.

Vegetation was assessed using the Line Transect method, through which vegetation cover was recorded and classified into functional categories in order to estimate patterns of land degradation and recovery. Soil and vegetation measurements were conducted according to locally recognized land-use types, namely *Ombanda*, referring to plains located above riparian zones (*Onakas*), generally situated on gentle slopes or intermediate landscape positions; Ongongo, representing upland areas primarily cultivated during the rainy season; *Otchumbo*, consisting of small agricultural plots located near settlements and typically used during the rainy season; and *Onaka*, corresponding to lowland areas located along river margins and generally characterized by the accumulation of water and organic matter. Additional land-use categories included pasture areas and small forest patches.

2.5 Socioeconomic Instruments and Data Analysis

The socioeconomic assessment was based on semi-structured interviews conducted with randomly selected individuals in the study sectors. The sampling design followed a spatial approach, integrating socioeconomic information with biophysical indicators through georeferenced grid sampling (2 km²) generated within a Geographic Information System (GIS) environment using QGIS 3.16, with sampling points spaced at 1 km intervals.

The interviews, which lasted approximately 45 minutes, were conducted with land users identified along the transects, household representatives, and key community informants. The questionnaire included both closed-ended and open-ended questions addressing household characteristics, asset ownership, livelihood sources, land tenure arrangements, livestock ownership, agricultural production systems, land management practices, fertilizer use, soil preparation methods, and local perceptions regarding soil degradation and existing support measures. These variables were selected to assess the socioeconomic conditions of rural households and their relationship with land degradation processes and Sustainable Land Management (SLM) practices. The main dimensions assessed and the corresponding variables investigated are summarized in Table 1.

Tabela 1– Main dimensions and variables assessed through the socioeconomic questionnaire.
Table 1– Principais dimensões e variáveis investigadas por meio do questionário socioeconómico.

Dimension Assessed	**Variables Investigated**
Household Characteristics	Household size, education level, labor availability
Livelihoods and Assets	Income sources, livestock ownership, productive assets
Land Tenure	Land access and land management arrangements
Agricultural Practices	Cropping systems, fertilizer use, soil preparation methods
Sustainable Land Management (SLM) Practices	Crop rotation, contour farming, fallow, soil cover practices
Perceptions of Land Degradation	Soil fertility decline, erosion, gullies, vegetation cover changes
Institutional Support	Technical assistance, training, access to agricultural inputs

Source: Authors (2025).
Fonte: autores (2025).

The collected data were coded and analyzed using descriptive statistics and thematic interpretation techniques. The results were subsequently integrated with the biophysical indicators obtained through the FAO-LADA framework to identify relationships between socioeconomic conditions, land management practices, and observed land degradation processes.

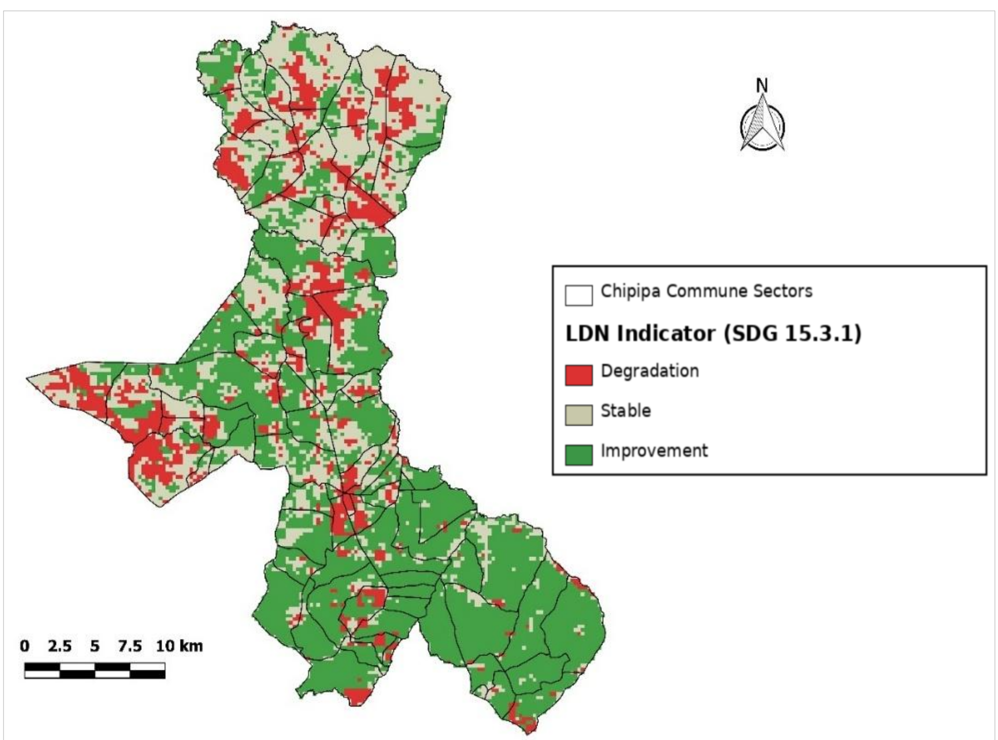
3. Results

The application of the FAO-LADA methodology in the Chipipa commune made it possible to identify differentiated spatial patterns of land degradation in the Ngunga and Lomanda 2 sectors, highlighting the coexistence of areas with different levels of degradation (Hot, Bright, and Stable). These patterns reflect the interaction between biophysical factors and land-use practices, in line with the holistic approach proposed by the LADA framework.

3.1 Spatial Patterns of Land Degradation

Figure 3 shows the spatial distribution of land degradation levels in the Chipipa commune based on the SDG 15.3.1 indicator. A heterogeneous spatial pattern was observed, with Degraded zones concentrated in areas subjected to greater anthropogenic pressure, contrasting with Bright and Stable zones, which are more sparsely distributed.

Figure 3 – Land Degradation Neutrality (LDN) map of the observed sectors in Chipipa commune, showing the spatial distribution of Hot, Bright and Stable zones.
Figura 3 – Mapa do indicador de Neutralidade da Degradação de Terras (LDN) nos sectores observados na comuna da Chipipa, evidenciando a distribuição espacial das zonas Hot, Bright e Stable zones

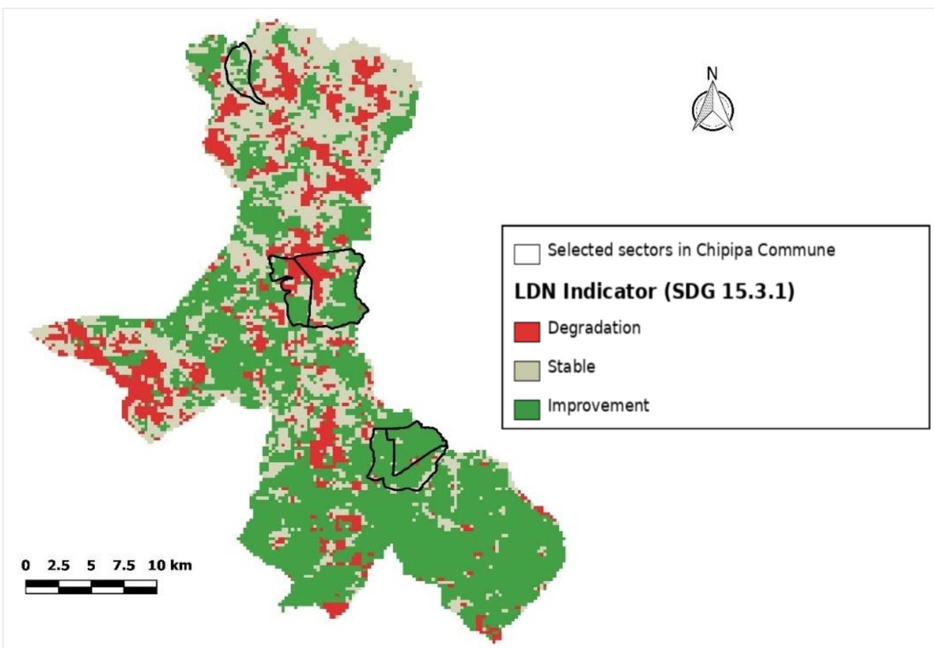


Source: Authors (2025).
Fonte: Autores (2025).

This pattern indicates the coexistence of critical degradation areas with sectors that maintain greater environmental stability or show signs of recovery. These differences reflect variations in land-use types, intensity of human activities, and the conservation status of natural resources.

Figure 4 presents the spatial detail of the SDG 15.3.1 indicator in the selected sectors of Ngunga and Lomanda 2, validated through field observations. The map highlights the predominance of Hot zones, associated with reduced land productivity, whereas Bright and Stable zones correspond to areas with greater vegetation cover, better ecosystem functionality, and more favorable conditions for agricultural production.

Figure 4 – LDN indicator and land productivity in the Ngunga and Lomanda 2 sectors (Chipipa), highlighting the Hot, Bright, and Stable zones.
Figura 4 – Indicador LDN e produtividade da terra nos sectores Ngunga e Lomanda 2 (Chipipa), destacando as zonas Hot, Bright e Stable.



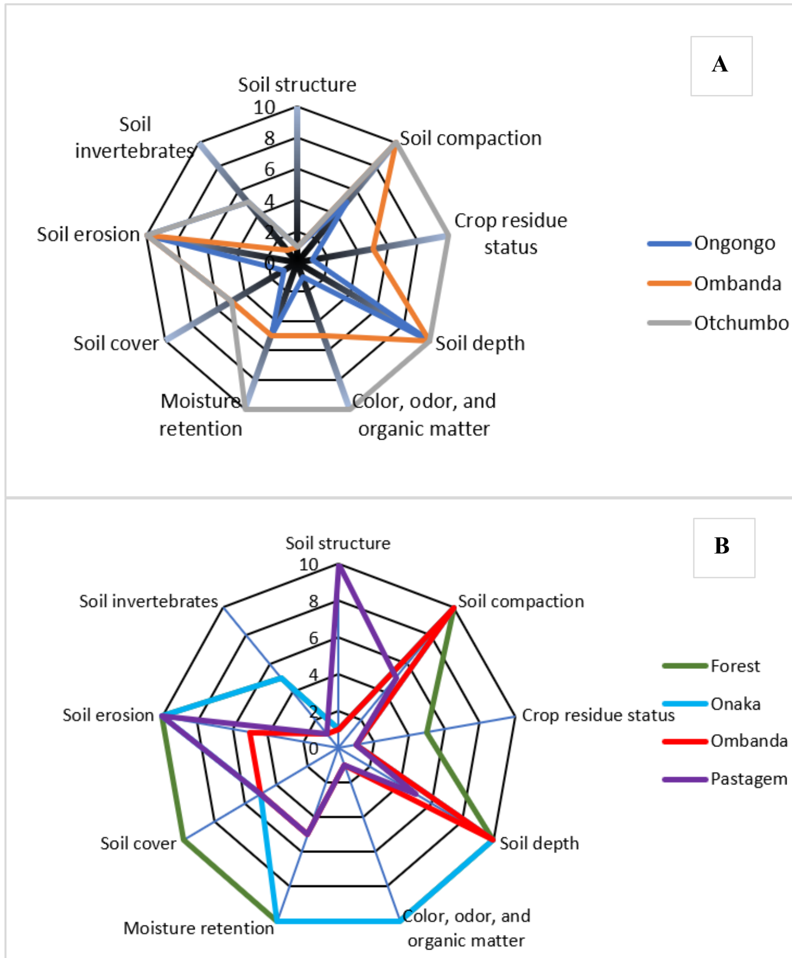
Fonte: Autores (2025).
Source: Authors (2025).

These results confirm the consistency between remote sensing data and field observations, reinforcing the suitability of the FAO-LADA methodology for identifying priority areas for monitoring and intervention.

3.2 Soil Biophysical Indicators

The soil biophysical indicators observed in the Ngunga and Lomanda 2 sectors revealed contrasting patterns according to the different land-use types (Figure 5). In both sectors, soil compaction and erosion emerged as the main degradation processes, with greater intensity associated with Ombanda, Ongongo, and pasture areas, indicating limitations in water infiltration and increased susceptibility to topsoil loss.

Figure 5 – Soil biophysical indicators obtained through Visual Soil Assessment (VSA) in the Ngunga (A) and Lomanda 2 (B) sectors, according to different land-use types.
Figura 5 – Indicadores biofísicos do solo obtidos por Avaliação Visual do Solo (VSA) nos sectores de Ngunga (A) e Lomanda 2 (B), segundo os diferentes usos de solo



Source: Authors (2025).
Fonte: Autores (2025).

The Onaka areas consistently presented better moisture conditions and more favorable indicators of soil structural and organic quality. In contrast, forest areas (in Lomanda) showed the best biophysical performance, characterized by greater soil cover, improved soil structure, higher moisture retention, and reduced erosion.

Conversely, Otchumbo areas (in Ngunga) and Ombanda areas displayed intermediate conditions, with signs of compaction related to intensive land use. Overall, the results indicate that soil functionality in both sectors is strongly influenced by land use and landscape position, highlighting the need for differentiated Sustainable Land Management (SLM) strategies adapted to each land-use unit.

3.3 Vegetation Biophysical Indicators

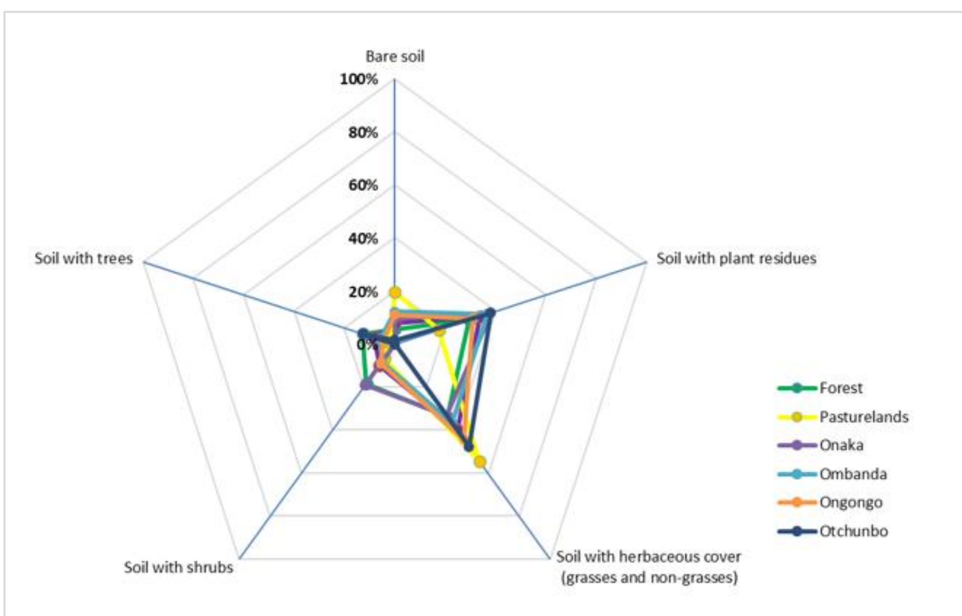
Vegetation analysis, conducted at the aggregated level for the study area, revealed distinct patterns of vegetation cover and structure according to land-use types. In general, herbaceous vegetation constituted the dominant stratum, particularly in pasture areas, Ombanda, and Ongongo, reflecting systems under higher land-use intensity and structural simplification of vegetation.

Forest areas showed a higher proportion of tree cover and a lower occurrence of bare soil, indicating better vegetation conservation status and greater soil protection. The Onaka areas exhibited an intermediate pattern characterized by high herbaceous cover and a significant presence of plant residues, suggesting favorable conditions for maintaining soil cover, although with limited arboreal stratification.

Agricultural land uses, particularly Ongongo and Otchumbo, presented a higher proportion of soil covered by plant residues and episodes of bare soil associated with cultivation practices and seasonal crop dynamics. The presence of shrubs was generally low across all land-use types, indicating limited secondary woody regeneration in the landscape.

Overall, the results indicate that vegetation structure is strongly conditioned by land use. Areas with lower anthropogenic intervention are associated with greater structural complexity and better soil cover, whereas agricultural and grazing areas exhibit simplified vegetation patterns and higher vulnerability to degradation processes (Figure 6).

Figure 6 - Biophysical indicators of vegetation according to land use in the study sectors
Figura 6 - Indicadores biofísicos da vegetação segundo o uso do solo nos sectores de estudo



Source: Authors (2025).
Fonte: autores (2025).

The patterns observed in Figure 6 indicate that vegetation cover varies according to land-use type, reflecting differences in management practices and levels of human intervention. Forest areas were characterized by a greater presence of tree cover and lower exposure of bare soil, suggesting more favorable conditions for soil protection and ecological stability. In contrast, agricultural and grazing areas showed a predominance of herbaceous vegetation and plant residues, indicating the important role of ground cover in reducing soil exposure. The generally low occurrence of shrubs across all land-use types suggests limited woody regeneration within the study area. Overall, these results highlight the influence of land use on vegetation structure and reinforce the importance of maintaining adequate vegetation cover as a strategy for mitigating land degradation and promoting sustainable land management.

3.4 Socioeconomic Indicators

The results of the socioeconomic assessment, presented in Table 2, indicate a context of high socioeconomic vulnerability and strong dependence on subsistence smallholder agriculture in the study sectors. The predominance of agricultural livelihoods, combined with the low ownership of medium and large livestock, suggests limited productive capital and restricted investment capacity among households.

Table 2– Socioeconomic characterization and perceptions of land degradation in the study sectors
Tabela 2– Caracterização socioeconómica e perceções de degradação da terra nos sectores de estudo

Analyzed dimension	Dominant observed result	Socio-environmental interpretation
Livelihoods	Predominance of smallholder agriculture	Direct dependence on natural resources
Livestock ownership	Higher frequency of small animals (poultry); low cattle ownership	Low productive capital and limited economic capacity
Land access	Predominance of privately managed land	Relative land tenure security, with pressure on common lands
Main perceived types of degradation	Decline in soil fertility and occurrence of gullies	Convergence between local perception and biophysical indicators
Adopted SLM practices	Contour farming, soil cover, crop rotation, and fallow	Partial and often unplanned adoption
Fertilizer use	Predominance of chemical fertilizers; limited use of organic fertilizers	Dependence on external inputs and low use of local resources
Soil preparation	Manual (hoe); very limited use of animal traction	Technological constraints and low mechanization
Production purpose	Predominantly for self-consumption; limited sales	Vulnerable agricultural systems with weak market integration

Source: Authors (2025).
Fonte: autores (2025).

Access to land is predominantly private, although the complementary use of communal land occasionally reflects pressure on shared resources and potential land-use conflicts. Local perceptions consistently identified declining soil fertility and the occurrence of gullies as the main land degradation problems, corroborating the biophysical indicators observed in the field.

Despite economic limitations, some Sustainable Land Management (SLM) practices were observed, including contour farming, soil cover management, crop rotation, and fallow practices. However, these practices are often implemented in an unplanned manner, frequently as a response to declining soil fertility.

Fertilizer use is dominated by chemical inputs, while soil preparation is predominantly manual using hoes, reflecting low mechanization and technological constraints. Agricultural production is mainly oriented toward self-consumption, with limited commercialization, characterizing farming systems that are weakly integrated into markets and highly vulnerable to environmental and climatic shocks.

4. Discussion

The spatial patterns identified in the study highlight the heterogeneous nature of land degradation within the study area, with the coexistence of critical zones (Hot) and areas that remain relatively stable or show signs of recovery (Bright and Stable). This behavior is typical of tropical agricultural landscapes dominated by smallholder farming systems, where the intensity of land use and management practices varies spatially, resulting in different levels of pressure on natural resources (Prăvălie, 2021).

Similar results were observed in other agricultural landscapes of Angola's central plateau evaluated under the FAO Sustainable Land Management program, such as in the localities of Chipipa, Alto Hama, and Chongoroi (FAO, 2023). In these areas, recent land cover maps indicate highly heterogeneous landscapes characterized by the coexistence of forests, agricultural lands, and open savannas, reflecting land-use mosaics associated with smallholder agriculture and the dynamics of agricultural expansion. For example, in Chipipa forests (39%), croplands (30%), and savannas/grasslands (18%) are predominant, while in Alto Hama a similar distribution is observed among forests (35%), croplands (32%), and savannas (22%). In Chongoroi, despite the greater dominance of forests (57%), the presence of shrublands and bare soils indicates localized pressures on ecosystems. This regional context reinforces the interpretation that land degradation occurs in a spatially differentiated manner, reflecting the interaction between biophysical factors, land-use dynamics, and the livelihood strategies of rural communities.

He correspondence observed between Hot zones and low levels of land productivity reinforces the applicability of the Land Degradation Neutrality (LDN) framework as a tool for identifying priority areas for intervention (FAO, 2022).

The field validation of patterns derived from remote sensing confirms the robustness of integrating spatial data with local observations, as highlighted in recent studies that emphasize the importance of combining biophysical indicators within situ verification for reliable land degradation assessments (Ghosh et al., 2024). These results demonstrate that the degradation observed in the study area is not a uniform process but rather the result of interactions between environmental conditions and human activities.

The predominance of soil compaction and erosion as the main degradation processes in the studied sectors is consistent with recent evidence identifying these factors as key drivers of soil functionality loss in agricultural systems characterized by low mechanization and intensive land use (Lal, 2015; Zhang et al., 2024). The greater occurrence of these processes in Ombanda, Ongongo, and pasture areas indicates that soil exposure and frequent disturbance of the surface layer significantly increase vulnerability to degradation, as reported in several studies on tropical and subtropical agricultural systems (Lal, 2015).

Conversely, the better biophysical conditions observed in Onaka areas and forest patches highlight the role of vegetation cover and organic matter in maintaining soil structure, moisture retention, and biological activity. Previous studies demonstrate that landscape position, together with hydrological conditions and vegetation cover, exerts a direct influence on soil resilience to degradation (Pennock et al., 1987). These findings reinforce the need for Sustainable Land Management (SLM) strategies tailored to different land-use systems.

The analysis of vegetation biophysical indicators revealed that vegetation cover and composition vary primarily according to land use. The dominance of herbaceous vegetation in agricultural and grazing areas reflects systems with simplified vegetation structure, which are associated with greater soil exposure and intensified erosion processes, as widely reported in studies on land-use change and environmental degradation (Lal, 2015; Prăvălie et al., 2020).

In contrast, forest areas show greater structural complexity and lower occurrence of bare soil, confirming the important role of tree vegetation in soil protection and the regulation of hydrological processes. The literature highlights that maintaining vegetation cover is one of the most effective mechanisms for conserving soil ecosystem services and increasing agroecosystem resilience (Nicholls et al., 2004; FAO, 2016).

The socioeconomic results indicate that land degradation is strongly associated with the vulnerability of rural communities. The predominance of subsistence farming, low productive capital, and limited mechanization restrict the consistent adoption of conservation practices, a phenomenon widely documented in smallholder farming systems in developing countries (Constantino, 2019; Kpienbaareh et al., 2024).

The convergence between local perceptions of declining soil fertility and the biophysical indicators observed in the field reinforces the relevance of local knowledge as a complement to technical assessments. However, the adoption of Sustainable Land Management practices often occurs in a reactive manner, reflecting limitations in access to technical assistance and effective public policies (FAO, 2016).

Overall, the results demonstrate that land degradation in the study area results from the interaction between soil biophysical fragility, simplification of vegetation cover, and socioeconomic constraints. The literature indicates that effective interventions require integrated approaches that combine agroecological practices, institutional strengthening, and policy support for smallholder agriculture (Costanza, de Groot, et al., 2014; Kpienbaareh et al., 2024). In this context, the application of the FAO-LADA methodology proved appropriate for capturing the complexity of land degradation processes and supporting strategies aimed at Sustainable Land Management.

5. Conclusion

The application of the FAO-LADA methodology revealed a heterogeneous spatial pattern of land degradation in the Chipipa commune, with the coexistence of Hot, Bright, and Stable zones associated with different land-use conditions. Soil compaction and erosion were identified as the main degradation processes, particularly in Ombanda, Ongongo, and pasture areas, while Onaka areas and forest patches exhibited better soil quality and vegetation cover indicators.

The vegetation assessment showed a predominance of herbaceous cover in agricultural and grazing systems, whereas forest areas presented greater tree cover and lower occurrence of bare soil, indicating more favorable conditions for soil protection. Socioeconomic results revealed a strong dependence on smallholder agriculture, low productive capital, predominance of self-consumption-oriented production, and limited adoption of Sustainable Land Management (SLM) practices.

Overall, the results demonstrate that land degradation in the study area results from the interaction between biophysical constraints and socioeconomic vulnerability. The FAO-LADA methodology proved to be an effective tool for identifying priority intervention areas and supporting the planning of Sustainable Land Management strategies in smallholder agricultural systems.

6. Acknowledgements

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7. References

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