Applying LADM in Evaluation of Forest Management for SDG 15.1.1 and 15.2.1 with case studies in different countries

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1 Introduction

In the quest for sustainable development, forest management has emerged as a critical area of focus, especially under the United Nations Sustainable Development Goals (SDGs), particularly targets 15.1.1 and 15.2.1. These goals emphasize the importance of conserving and sustainably managing forest resources to maintain ecological balance and support human livelihoods. In this context, this study proposes the application of the Land Administration Domain Model (ISO19152 - LADM) as a novel approach to assess and enhance the effectiveness of forest management strategies. This research aims to explore the added value of LADM in providing a comprehensive and structured analysis of forest tenure, rights, and responsibilities, thereby aligning forest management practices with the objectives of the SDGs. By integrating LADM's systematic framework into the evaluation process, this study seeks to offer new insights and methodologies for achieving sustainable forest management, a critical component of global environmental sustainability and economic development.

1.1 Scientific relevance

This study holds scientific significance as it explores the intersection of land administration and forest management. It aims to establish a robust framework for assessing the SFM, aligning with SDGs. The findings have the potential to inform policymakers, land administrators, and conservationists about the value of adopting standardized land administration models like LADM in fostering SFM practices. Furthermore, this research contributes to the broader discourse on sustainable development, highlighting the pivotal role of land management in achieving the SDGs.

2 Related work

2.1 SDGs and Forest Management

The intersection of the UN SDGs with forest management is particularly pronounced in goals 15.1.1 (sdg (2023a)) and 15.2.1(sdg (2023b)).These goals underscore the importance of sustainable forest management and the prevention of deforestation and degradation. For every indicator, there is a SDGs metadata document, which contains the definitions, calculation methodologies, and data sources, offering a general method for evaluating the indicators. For SDG 15.1.1 and SDG 15.2.1, the data are primarily collected by the Food and Agriculture Organization (FAO) through the Global Forest Resources Assessment (FRA) (Food and of the United Nations (2018)).

Figure 1: SDG 15.1.1 and 15.2.1 Data Source

Report from the FRA suggests a variety of data sources employed in forest management. Searches using these sources as keywords have revealed a growing focus on utilizing remote sensing to directly obtain land cover data, such as full cover forest/vegetation maps (Tarantino et al. (2023)), or to improve the efficiency of National Forest Inventories(Lister et al. (2020)). However, while remote sensing can provide spatial data, it falls short in offering detailed information on sub-indicators related to laws, policies, and management plans. This gap in data coverage can be effectively bridged by the LADM, which integrates these crucial aspects, offering a more holistic approach to forest management

and conservation.

2.2 Introduction to the LADM

ISO 19152, the Land Administration Domain Model (LADM), is a prominent international standard in the field of land administration providing a comprehensive framework that defines conceptual models and standardized methodologies for land administration systems. Its technical aspects focus on three core components: parties (people and organizations), rights, restrictions, and responsibilities (RRR), and spatial units (parcels and properties). The primary goal of this standard is to facilitate communication among various parties, both domestically and internationally, by providing a shared vocabulary (ontology) and a formal language (Unified Modeling Language, UML) to describe people-to-land relationships.

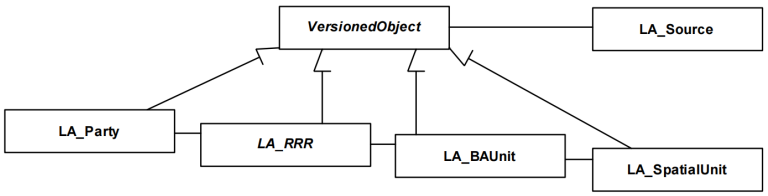

Figure 2: Basic classes of the core LADM

LADM does not intend to replace existing systems but rather serves as a descriptive tool for these systems, enhancing the comprehension of their similarities and differences. While LADM is a generic model, it can be extended and customized for specific regions or countries. Its versatility and adaptability extend far beyond conventional land administration practices, serving as a powerful instrument for addressing contemporary global challenges.

2.3 Interlinking LADM and SDGs

In the field of sustainable development, when van Oosterom et al. (2019). revised the first version of the LADM back in 2019, they specifically emphasized that further objectives of the revision included the creation of reliable land management indicators for the SDGs. This early foundation pointed the way for subsequent exploratory research on various applications of LADM, such as that conducted by Unger et al. (2021). . Additionally, the connection between the SDGs and LADM has been comprehensively examined by Chen et al.

(2023), who developed a systematic methodology to distill SDG indicators and represent them using UML diagrams based on LADM. Furthermore, LADM's application extends to various SDG domains, including disaster management for SDG 1 and SDG 3 (Unger et al. (2019)), rural land tenure reform (Xu et al. (2022)), and gender equality in land administration (Unger et al. (2023b); Lemmen et al. (2019); Unger et al. (2023a)). These studies collectively underscore LADM's utility and adaptability in advancing sustainable development objectives across diverse fields.

While LADM has found applications in various SDG domains, its use specifically within the forest sector under the SDG framework remains limited. However, scholars have begun to explore and apply LADM in the broader context of forest management.

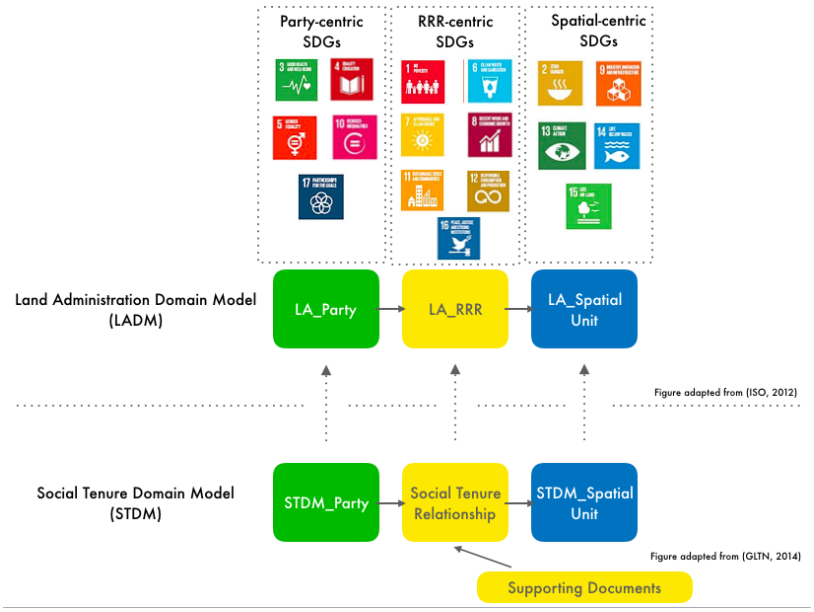

Figure 3: LADM as a base to support the SDGsUnger et al. (2021)

2.4 LADM in Forest Management

The application of the LADM in forest management represents an emerging and significant area of exploration. LADM's framework, which emphasizes the structuring and management of land rights, responsibilities, restrictions, and spatial units, offers a unique perspective in addressing forest management challenges(Arnante (2023)). This approach is particularly relevant in the context of sustainable forest management, where the complexities of land tenure,

rights, and ecological considerations intersect. One of the key advantages is its potential to bridge data gaps. While remote sensing technologies provide extensive spatial data, they often fall short in capturing the legal and policy aspects crucial. LADM can integrate these spatial data with information on legal rights, restrictions, and responsibilities, offering a more comprehensive view of forest resources.
However, research specifically focusing on LADM for forest management is relatively scarce. Most studies integrate forest themes within broader topics. For instance, Paixão et al. (2013) examines the use of LADM to define the land rights of indigenous tribes in Brazil, with an emphasis on forest deforestation issues. Yu et al. (2017) and Xu et al. (2019) respectively cover the unified registration of real estate and natural resource management in China, including forests. On the other hand, more works focus on forest management cadasters, like Kononova and Zatolokina (2020) discussing the cadastral challenges in forest resource surveying in Russia's Belgorod Oblast; Vordoglou et al. (2019) examining the role of cadaster and forest maps in protecting urban forests.

While the application of LADM in forest management is still in its early stages, the insights gained from the studies mentioned indicate a growing recognition of its potential in this field. The integration of legal, policy, and spatial data through LADM offers a more holistic approach to forest management, addressing the multifaceted challenges of sustainability, rights, and ecological balance. This emerging area of research not only fills existing gaps in forest management practices but also aligns closely with the global pursuit of sustainable development goals.
However, the specific application of LADM to forest management, particularly within the context of the SDGs, necessitates further exploration. This leads to the primary research question of this study, which seeks to understand the added value of LADM in enhancing the sustainable management of forests. The inquiry extends to various dimensions of forest management, including data organization, interoperability of existing models with LADM, and the registration of forest-related rights and responsibilities.

3 Research questions

The main research question of this study is:
What is the added value of using the Land Administration Domain Model (ISO19152 - LADM) to assess the sustainable management of forests in the context of UN Sustainable Development Goals (SDG indicators 15.1.1 and 15.2.1)?

And the sub-questions are as follows:

- How can various types of forest-related data be effectively organised and registered in the context of LADM?
- What forest information models currently exist? How do these models interoperate with LADM to support sustainable forest management?
- How to register forest-related rights, restrictions and responsibilities (RRR), and policy documents in LADM? How to model different levels of governance (high level/general policy and low level/individual)?

3.1 Scope of research

In scoping the study, the following key areas will be focused on:

- Focus mainly on forest management under SDG indicators 15.1.1 and 15.2.1;
- Focus on legal facts attached to forest management;
- Deeply analyse the potential value of LADM and explore its role in less ambiguous definition, more accurate indicator values, more efficient indication computation and so on;
- Consider cases from different countries/regions to fully understand the applicability of LADM in different contexts.

4 Methodology

1. Case study selection

   The study will involve a comparative analysis across three countries, each representing a distinct geographical and socio-economic context.

   - Europe: Greece or Sweden, representing advanced forest management practices in Europe.
   - Asia: China or Indonesia, reflecting the diverse forest management challenges and approaches in Asia.
   - Americas: Brazil or Canada, showcasing forest management in the context of large, biodiverse landmasses.

2. Data Collection

   More details in Section 6

3. Apply LADM in Data Processing

   - Calculation of SDG Indicators: Use LADM-processed data to calculate the values for SDG indicators 15.1.1 and 15.2.1, following the SDGs metadata document's methodologies.
   - LADM Framework Utilization: Process the collected data through the LADM framework, focusing on the conversion of forest-related spatial and legal data into formats aligning with the LADM structure.
   - Indicator Calculation with LADM: Utilize the LADM framework to calculate SDG 15.1.1 and 15.2.1 indicators, focusing on how LADM contributes to more comprehensive or accurate representations of forest management status.

4. Comparative Analysis

   - Comparison with Official SDG Data: Compare the LADM-calculated values with the official SDG data for each country to identify discrepancies, similarities, and potential reasons for any variances.
   - Cross-country Comparison: Evaluate the efficacy of LADM in different countries, highlighting its role in improving data quality, decision-making processes, and policy implementation.

5. Evaluation of LADM's Effectiveness

- Effectiveness in Indicator Calculation: Assess how effectively LADM data aligns with or diverges from the official SDG data, and what this indicates about LADM's utility in forest management.
- Effectiveness in Enhancing Forest Management: Assess the extent to which LADM contributes to more effective forest management as compared to traditional methods.
- Value Addition in Sustainable Development: Discuss how LADM adds value to achieving SDGs in forest management, particularly in terms of sustainability, accuracy, and policy relevance.

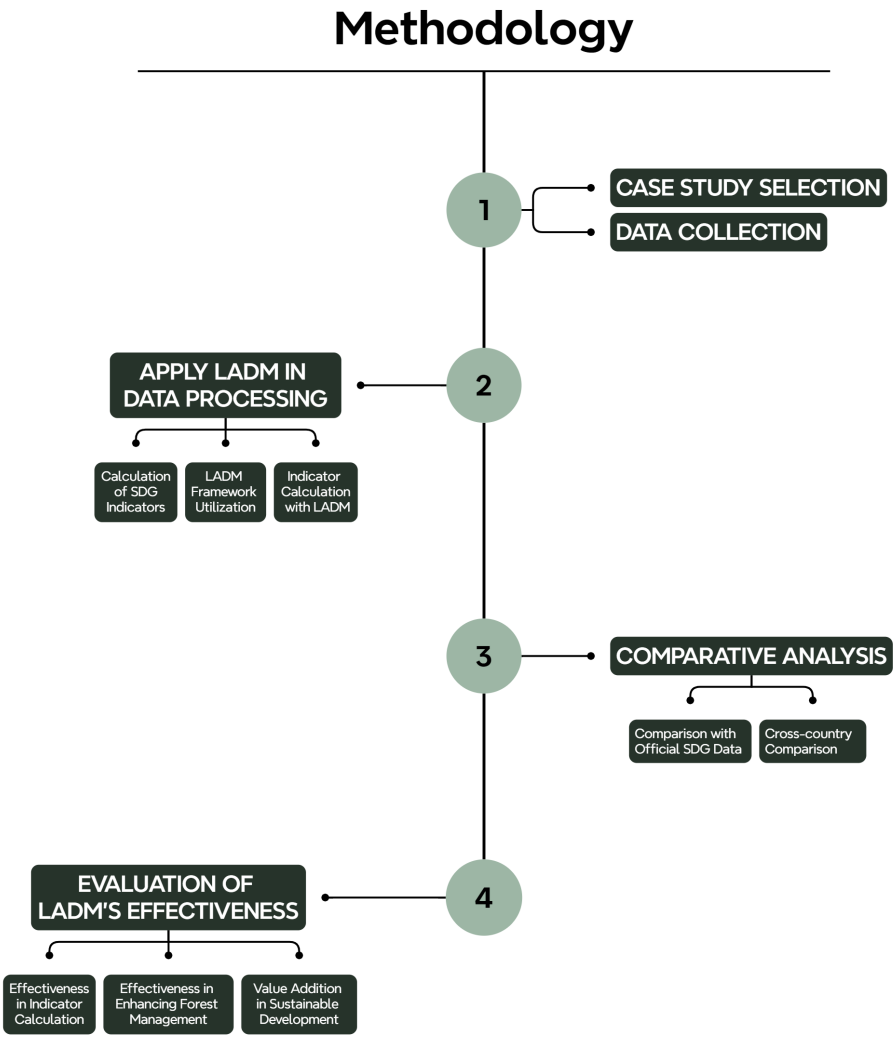

Figure 4: Research Methodology

5 Time planning

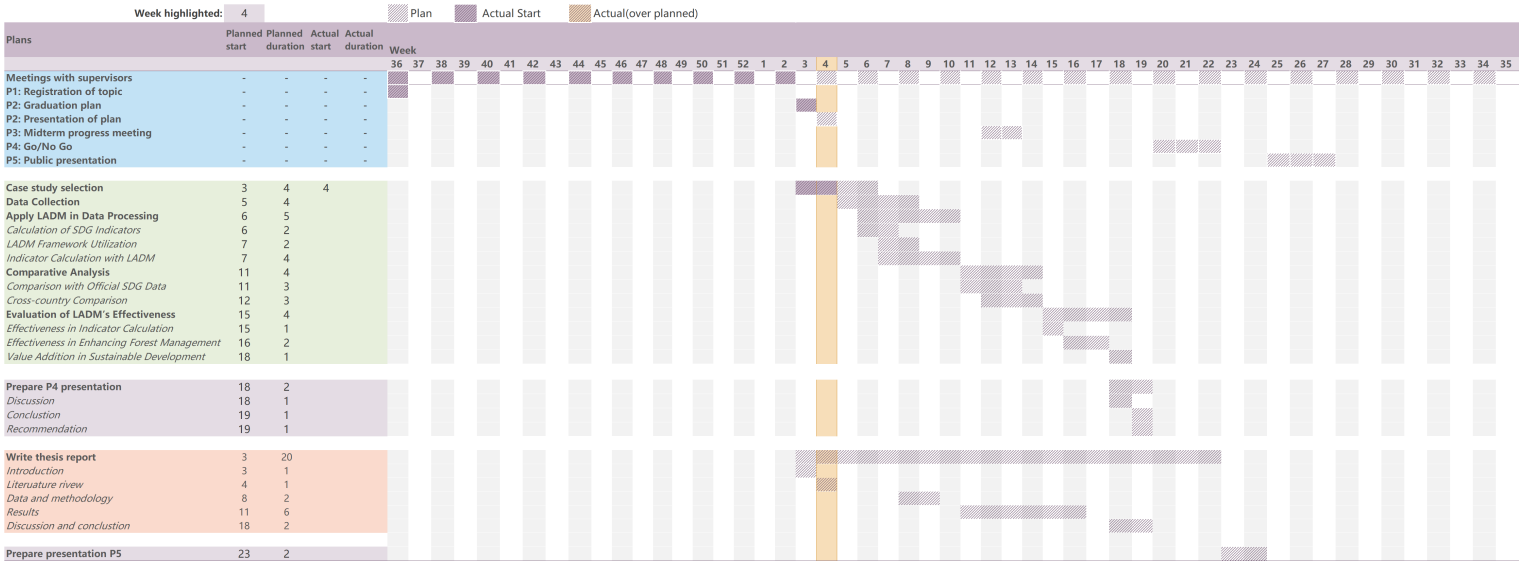

Figure 5: Time Planning

6 Tools and datasets used

6.1 Tools

1. UML Modeling Tools (Enterprise Architect, Visual Paradigm Online): For modelling and visualizing the LADM framework and its application to forest management data.

2. Database Management Systems (PostgreSQL with PostGIS): For storing and managing both spatial and non-spatial data, ensuring they are structured in line with LADM.

3. Data Analysis Tools (R, Python): For statistical analysis and data processing. Python, with libraries such as Pandas and NumPy, will be particularly useful for handling large datasets and performing complex calculations.

4. GIS Software (QGIS/ArcGIS): For spatial data analysis and visualization.

5. Remote Sensing Tools (ERDAS Imagine, ENVI): To process satellite imagery and other remote sensing data for forest cover assessment.

6.2 Datasets

1. Official SDG Indicators Data:
   Source: United Nations for SDG 15.1.1 and 15.2.1
   Purpose: use as a benchmark for comparison.

2. Highly accurate forest cover maps.
   Source: Kadaster International or other similar organizations.
   Purpose: Used to accurately analyze and monitor changes in forest cover, as well as to calculate annual rates of change in forest area.

3. Legally established GIS data layers for protected areas.
   Source: National Park Service, environmental protection agency or relevant government department.
   Purpose: Used to determine the proportion of forest area within legally protected areas.

4. General Policy Document.
   Source: Government legal databases, guidelines or regulations issued by international organizations.
   Use: To analyze and understand macro policies and regulations that affect forest management and how they define forest management practices at the national or regional level.

5. Individual Level Documents.
   Source: local government, forest service, or related department.
   Use: To obtain information on forest resource tenure rights specific to an individual or organization, such as harvesting permits, land use rights certificates, etc.

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