A Hierarchical Land-Use Classification Framework for GIS-Based Spatial Decision Support Systems in Sri Lanka

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Abstract

The absence of a unified and standardized land-use classification system in Sri Lanka has constrained the effective application of Geographic Information Systems (GIS) and Spatial Decision Support Systems (SDSS) in urban and regional planning. This study aimed to develop a hierarchical and context-sensitive land-use classification framework suitable for SDSS integration, focusing on the Ella Pradeshiya Sabha area. The research combined institutional review, field-based land and building surveys, and expert consultations to identify data inconsistencies and design an adaptable classification structure. The resulting framework consists of three hierarchical levels—Land Cover, Land Use, and Land Use Based on Character—supported by standardized coding, mapping scale, and accuracy parameters. The system harmonizes institutional variations, captures tourism-oriented land uses, and enhances spatial interoperability. The study concludes that such an integrated classification model strengthens evidence-based zoning, improves data-driven planning, and supports sustainable spatial governance in Sri Lanka.

Keywords: Classification Framework; Geographic Information System (GIS); Land Use; Spatial Decision Support System (SDSS); Sri Lanka

Introduction

Land use classification represents a fundamental component of spatial planning and land management, as it defines how different land parcels are organized, interpreted, and regulated within a planning framework. A well-structured classification enables planners to analyse spatial data systematically, identify suitable development zones, and evaluate environmental and socio-economic interactions that influence policy decisions (Carr & Zwick, 2007). In Sri Lanka, the absence of a unified and standardized classification system across planning institutions has limited the integration of spatial data for decision-support applications. Institutions such as the Urban Development Authority (UDA), the Survey Department, and the Land Use Policy Planning Department (LUPPD) use separate classification schemes tailored to their mandates, leading to inconsistencies in scale, terminology, and thematic detail.

This issue is particularly evident in rapidly urbanizing and tourist-oriented areas such as the Ella Pradeshiya Sabha, where residential, agricultural, conservation, and tourism-related land uses coexist within a limited area. The need for a coherent and GIS-compatible classification that reflects both national policy requirements and local development dynamics has therefore become crucial. Drawing upon international frameworks—such as the Anderson Land Use/Land Cover System (Anderson et al., 1976), Godschalk's Urban Functional Classification (Kaiser et al., 1995), and the UN Land Cover Classification

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System (FAO/UNEP, 2000)—this study develops a hierarchical and context-sensitive land use classification suited for integration into a Spatial Decision Support System (SDSS) for the Ella region.

Objective/s of the Study

The main objective is to develop a standardized and context-sensitive land-use classification framework suitable for SDSS integration within the Ella Pradeshiya Sabha area. The research seeks to answer several key questions: What are the existing international and national land-use classification systems, and how do they differ in structure and applicability? How can these frameworks be adapted to harmonize institutional variations and reflect the tourism-oriented land-use patterns of Ella? What technical parameters are essential for ensuring GIS compatibility and spatial accuracy? Through addressing these questions, the study aims to establish a practical and replicable classification model to support data-driven urban and regional planning in Sri Lanka.

Literature Review

Land-use classification provides the conceptual and analytical foundation for spatial planning and land management. It translates complex landscapes into structured categories that support evidence-based decision-making (Carr & Zwick, 2007). The literature consistently emphasizes that a well-designed classification system enhances spatial modelling, conflict detection, and scenario planning within Geographic Information Systems (GIS) and Spatial Decision Support Systems (SDSS) (Lotz, 2007; Carver, 1991). The sophistication of classification systems has evolved alongside technological progress, moving from static cartographic interpretations to dynamic, data-driven, and multi-scalar frameworks (Gormus et al., 2018).

Early global efforts, such as the Anderson Land Use/Land Cover Classification System (Anderson et al., 1976), established a hierarchical model that distinguished between general categories (e.g., built-up, agricultural, forest, and water) and detailed sub-classes suitable for remote-sensing interpretation. Anderson's model remains influential for its clear structure, mutually exclusive categories, and compatibility with raster datasets such as Landsat imagery. However, its strong emphasis on biophysical attributes offers limited insight into human functional relationships, which are critical in urban contexts.

To address this limitation, Godschalk's Urban Functional Classification (Kaiser et al., 1995) introduced a socio-functional perspective by categorizing land according to activity—residential, commercial, industrial, institutional, and recreational. This framework enables integration with socio-economic datasets and zoning regulations, thereby extending applicability to urban growth management and land-use control (Godschalk, 1988, as cited in Kaiser et al., 1995). Complementing these, the United Nations Land Cover Classification System (UN-LCCS) developed by FAO and UNEP (2000) offers a modular, rule-based design adaptable across spatial scales and environmental conditions. Its flexibility allows global harmonization of land-cover data and facilitates integration of biophysical and functional attributes, including temporal analysis and ecosystem-service components. Table 01 compares the core features of these three landmark systems, illustrating the conceptual diversity that informs modern classification design.

Table 01
Comparative Overview of Key Land-Use Classification Systems

Aspect	Anderson (1976)	Godschalk (1988)	UN-LCCS (FAO/UNEP 2000)
Primary focus	Land cover (biophysical)	Urban land-use functions	Combined physical & functional
Structural design	Hierarchical (4 levels)	Hierarchical with sub-classes	Modular, rule-based
Scale applicability	National → local	Urban/local	Global → local
Integration with remote sensing	High	Moderate	High
Flexibility	Moderate	High	Very high

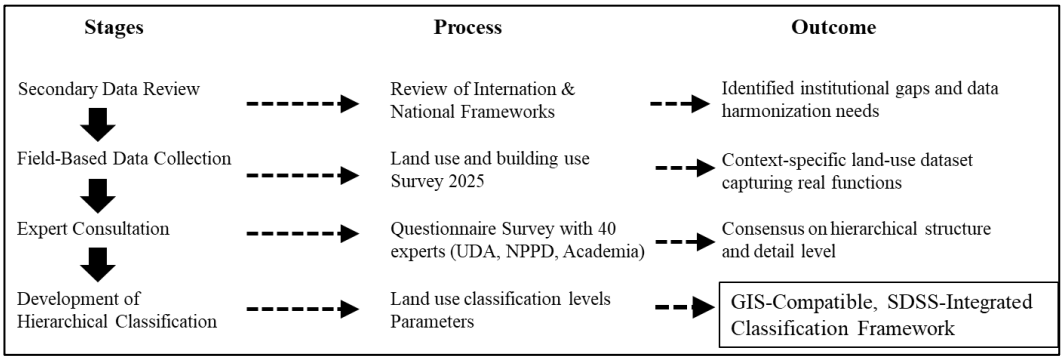
Source: compiled by author based on Anderson et al., 1976; Kaiser et al., 1995; FAO/UNEP, 2000.

While these systems provide valuable theoretical foundations, their direct application in Sri Lanka remains limited due to the absence of institutional harmonization. Agencies such as the Urban Development Authority (UDA), the Survey Department, and the Land Use Policy Planning Department (LUPPD) employ independent classification frameworks shaped by their mandates, producing fragmented and non-interoperable datasets (author's observation, 2025). Consequently, there exists a critical research gap in developing a unified, GIS-ready classification system that aligns with both international standards and the unique functional character of emerging tourist-oriented towns. Addressing this gap positions the present study to contribute original knowledge by formulating a hierarchical, standardized, and context-responsive classification capable of integration into SDSS platforms—thereby strengthening spatial planning, data sharing, and evidence-based decision-making in Sri Lanka.

Methods

The study followed a four-stage mixed-methods approach to develop a context-sensitive and GIS-compatible land-use classification system for the Ella Pradeshiya Sabha area (Figure 01).

Figure 01
Methodology



Source: Author developed (2025)

The first stage involved a comprehensive review of existing land-use classification frameworks at international and national levels. Global systems—Anderson's (1976) Land Use/Land Cover Classification, Godschalk's (1988) Urban Functional Classification (Kaiser et al., 1995), and the FAO/UNEP (2000) Land Cover Classification System—were compared with national schemes used by

the Urban Development Authority (UDA), Survey Department, and Land Use Policy Planning Department (LUPPD). This analysis identified inconsistencies, overlaps, and data-integration gaps across institutions.

The second stage comprised a Land Use and Building Survey (2025) documenting more than 3,000 parcels to record primary and secondary uses, including tourism-related activities such as homestays, hostels, cafés, and spas. Data were gathered through GPS-enabled field surveys, cadastral overlays, and structured observation forms. The third stage included an expert questionnaire survey involving 25 professionals from UDA, LUPPD, and academia to evaluate preferred classification detail and assess usability within a Spatial Decision Support System (SDSS). Descriptive statistics were used to determine consensus on system granularity and practicality.

Finally, the fourth stage synthesized the findings to formulate a three-level hierarchical classification—Land Cover, Land Use, and Land Use Based on Character—supported by standardized coding, a 1:10,000 mapping scale, minimum mapping units (0.25 ha urban; 0.5 ha rural), and an accuracy threshold of ≤ 5 m RMSE to ensure SDSS compatibility.

Results and Discussion

The study developed a context-specific, hierarchical land-use classification system for integration into a Spatial Decision Support System (SDSS) in the Ella Pradeshiya Sabha area. The results highlight key institutional and methodological gaps affecting spatial data consistency in local planning. A comparative review of the Urban Development Authority (UDA), Survey Department, and Land Use Policy Planning Department (LUPPD) frameworks revealed major inconsistencies in thematic detail, mapping scale, and functional focus. The UDA emphasizes built-up zoning categories for regulatory purposes, the Survey Department produces broad national land-cover maps, and the LUPPD prioritizes agricultural and resource-based uses. These variations result in overlapping datasets and weak data interoperability. Similar institutional fragmentation has been observed in other developing contexts, where agencies generate land-use data independently without standardized frameworks (FAO & UNEP, 2000; Lotz, 2007).

Table 02

Institutional variation in land-use classification systems in Sri Lanka

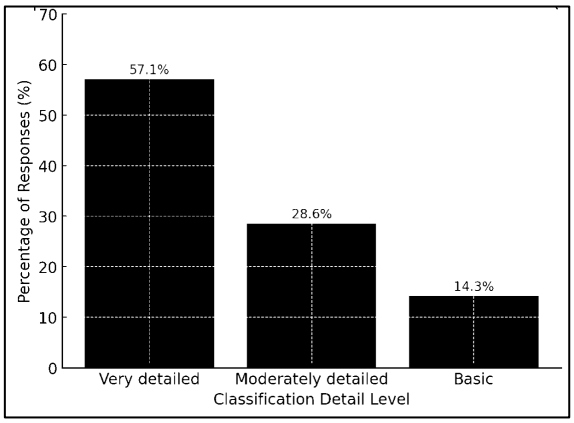
Institution	Thematic Emphasis	Mapping Scale	Strengths	Limitations
UDA	Built-up and zoning categories	1:10,000	Detailed urban classes	Weak representation of agriculture and conservation
Survey Department	National land cover	1:50,000	High positional accuracy	Broad, generalized classes

Source: Author compilation, 2025.

The 2025 Land-Use and Building Survey revealed that existing classifications fail to represent Ella's tourism-driven urban fabric. Mapping over 3,000 parcels showed a fine mix of residential, commercial, and tourism uses—such as homestays, hostels, cafés, and spas—largely absent in national datasets. These findings emphasized the need for a flexible and detailed system capable of capturing hybrid land uses common in tourism-oriented towns. An expert survey of 25 planners, land officers, and GIS professionals further validated this approach, with 57 percent favoring a detailed hierarchical model, 29 percent preferring a moderate version, and only 14 percent supporting a basic one. The consensus highlighted

that greater classification detail improves analytical precision and policy relevance in SDSS-based planning (Carr & Zwick, 2007).

Figure 02
Expert preferences for level of classification detail



Source: Author survey, 2025.

The findings led to a three-level hierarchical classification comprising Land Cover, Land Use, and Land Use Based on Character. The first level defines broad groups such as built-up, agriculture, and conservation; the second identifies functional uses like residential, commercial, industrial, tourism, and public; and the third distinguishes specific activities such as homestays, boutique hotels, and cafés. Each class was assigned an alphanumeric code (e.g., A1.1.5 for Homestays) to maintain clarity in GIS environments. The system was developed at a 1:10,000 scale with minimum mapping units of 0.25 hectares for urban areas and 0.5 hectares for rural or agricultural lands, ensuring ≤5 m RMSE spatial accuracy. These parameters conform to international mapping standards (Anderson et al., 1976; FAO & UNEP, 2000) and ensure compatibility with institutional and global datasets.

The new classification system overcomes the limitations of existing institutional frameworks by integrating biophysical, functional, and character-based dimensions within a single structure. It merges the hierarchical clarity of Anderson's model, the functional focus of Godschalk's framework, and the adaptability of the UN-LCCS (Anderson et al., 1976; Kaiser et al., 1995; FAO & UNEP, 2000). Embedded in a GIS environment, it supports spatial overlay, suitability analysis, and land-use conflict identification (Carver, 1991). The approach enhances planning precision in rapidly transforming regions like Ella and provides a replicable model for other Sri Lankan local authorities. It promotes spatial data interoperability, tourism-sensitive zoning, and evidence-based regulation aligned with national smart-planning initiatives.

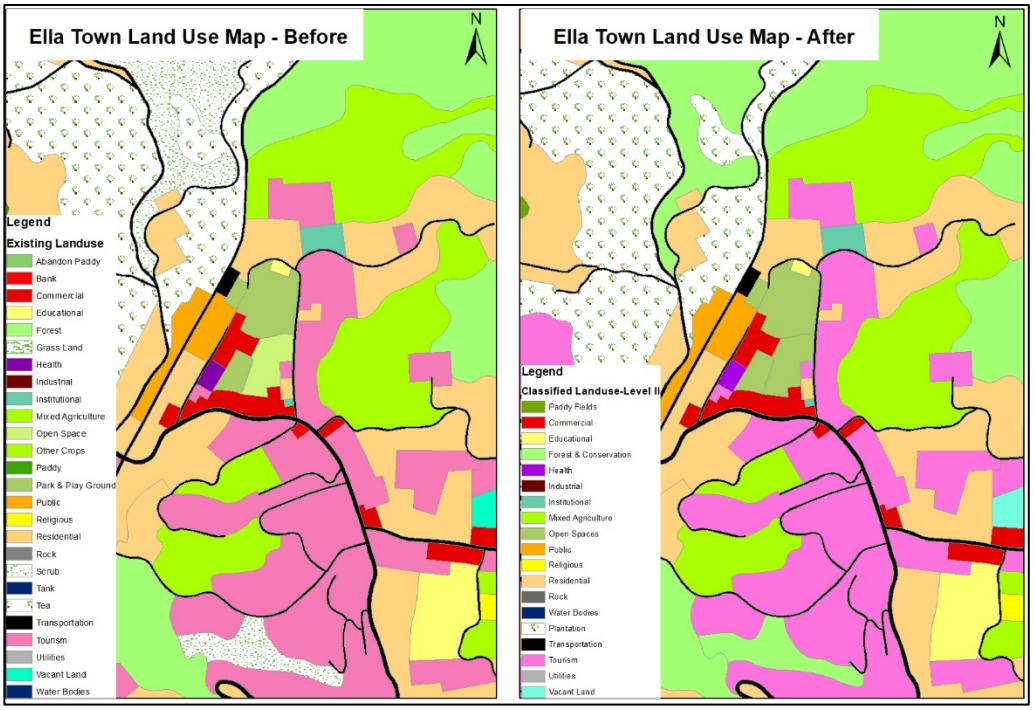
The developed classification system was applied to the Ella Town area to illustrate its practical use in spatial analysis and visualization. Figure 03 compares the land-use pattern before and after applying the Level II classification, demonstrating improved thematic detail and clearer differentiation of functional zones such as residential, commercial, tourism, and conservation areas. This enhanced representation confirms the effectiveness of the proposed framework in capturing the complex and tourism-oriented land-use dynamics of Ella.

Table 03
Sample extract from proposed land-use classification system

Level 01 - Land Cover	Level 02 - Land Use	Level 03 - Land Use Based on Character
A. Built-up Areas	A.1 Residential	A.1.1 Permanent Residential (Single/Detached)
		A.1.2 Mixed Residential–Commercial
		A.1.3 Rooms Only / Rental Units
		A.1.4 Hostels / Shared Housing
		A.1.5 Home Stays
		A.1.6 Under Construction / Vacant Residential Plots
	A.2 Commercial	A.2.1 Retail Shop
		A.2.2 Wholesale Shop
		A.2.3 Restaurant / Café
		A.2.4 Bank / Financial Services
		A.2.5 Laundry / Service Shops
		A.2.6 Mixed Commercial Use
		A.2.7 Office / Business Premises
		A.2.8 Under Construction / Vacant Commercial
	A.3 Tourism	A.3.1 Hotel
		A.3.2 Hostel / Dormitory
		A.3.3 Home Stay
		A.3.4 Rooms Only / Guest Rooms
		A.3.5 Restaurant / Café (Tourist-Oriented)
		A.3.6 SPA / Wellness Centers
		A.3.7 Tourism Mixed Use
		A.3.8 Under Construction / Vacant Tourism

Source: Author-developed classification, 2025.

Figure 03
Application of the Proposed Land Use Classification Framework in Ella Town



Source: Author developed (2025)

Conclusion

The study successfully developed a standardized and context-sensitive land-use classification system tailored to the Ella Pradeshiya Sabha area. By integrating insights from international frameworks, institutional analyses, field surveys, and expert evaluations, the research formulated a three-level hierarchical structure that captures both physical and functional land characteristics. The system establishes consistent coding, mapping scales, and accuracy standards necessary for integration into a Spatial Decision Support System (SDSS). It bridges institutional data gaps and introduces new categories that reflect tourism-oriented land uses often omitted from national frameworks. The findings emphasize that harmonized and GIS-compatible classification frameworks can substantially enhance planning precision, data interoperability, and evidence-based decision-making. The proposed model offers a replicable approach for other local authorities in Sri Lanka, strengthening spatial governance, supporting smart-city planning initiatives, and enabling sustainable management of land resources in rapidly transforming urban and rural environments.

Acknowledgement

The author gratefully acknowledges the support extended by the Urban Development Authority (UDA), Survey Department, and Land Use Policy Planning Department (LUPPD) for providing institutional data and technical insights essential to this research. Sincere appreciation is also extended to the survey

participants, including planning professionals and local officers, whose valuable inputs and field cooperation greatly contributed to the successful completion of the study.

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