National Land Use Zoning (NLUZ): A Harmonized Approach for Climate-Responsive Land Governance

Gonpo TENZIN, Chencho TSHERING, Pema WANGDA and Tika CHHETRI, Bhutan

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SUMMARY

The National Land Use Zoning (NLUZ) initiative in Bhutan is a crucial response to the challenges of harmonizing land use at the national level. The absence of a national spatial code and comprehensive land databases has led to inefficient resource management and insufficient climate-responsive governance. Despite numerous geospatial initiatives, the lack of an integrated spatial decision-making platform has hindered effective and climate-resilient land use practices. The NLUZ initiative addresses these issues by consolidating and harmonizing land use across the country, with a focus on promoting sustainable practices and enhancing climate resilience. This involves revalidating and delineating the country into nine macro, 23 micro, and 23 nano zones, each defined to specific uses that include climate-responsive objectives. This approach aligns with Bhutan's Gross National Happiness (GNH) principles and global climate commitments.

Internationally, NLUZ frameworks have been effective in guiding sustainable land management, with successful examples from countries like the United States, Germany, Japan, and Rwanda, as highlighted in the literature review as success models discussed in the paper. However, the success of such frameworks depends heavily on careful design and implementation, including the integration of scientific data and stakeholder inputs. Common challenges include land tenure issues, coordination among agencies, and the integration of traditional practices with emerging zoning concepts. In Bhutan, the NLUZ initiative is guided by a three-pronged technical approach, followed by land use assessments and conflict analysis from diverse perspectives, including an overlay analysis that incorporates climate-responsive considerations.

For the first time in Bhutan, the NLUZ initiative has been instrumental in integrating climate considerations into overall land use zoning, thereby enhancing resilience to climate-induced hazards and promoting sustainable resource use. Key components include the use of advanced GIS tools for spatial analysis and the delineation of Nature Conservation Areas, Sustainable Forest Management Areas, Forest Management Units, Community Forests, High Conservation Values, and other critical land uses. However, despite this consolidated approach, the initiative faces challenges related to data quality, technology, and governance. For example, approximately 35.43% of Bhutan's land remains unzoned, underscoring the need for more precise data and improved zoning practices. Drawing on insights from successful global models of harmonized land use systems, the paper recommends that Bhutan's NLUZ initiative continue

to refine its strategies, enhance its climate-responsive framework, and pursue further research to achieve its intended objectives.

1. INTRODUCTION

1.1 Background

Bhutan, like many countries, is grappling with the complexities of sustainable land use management amidst increasing climate variability. The National Action Program (NAP) to Combat Land Degradation highlights the absence of a cohesive national land use strategy, which has led to conflicts among various sectors regarding land use. This lack of coordination results in unsustainable land practices, which undermine the land's capability and exacerbate the effects of climate change.

The challenges are compounded by the sectoral driven programs aimed at harmonizing land use for climate-responsive actions. The absence of a coordinated institutional structure for overseeing the technical aspects of land use has led to fragmented and often contradictory developments, particularly near critical land use areas. These developments frequently result in the loss of valuable land resources, which could otherwise contribute to socio-economic growth and environmental sustainability.

In response, the National Land Use Zoning (NLUZ) initiative has been launched as a collaborative effort among various stakeholders (RGoB, 2018). The goal is to create a harmonized and sustainable land use system that aligns with Bhutan's national and international commitments to climate-responsive land governance. The NLUZ aims to ensure the efficient and judicious use of Bhutan’s limited land resources by establishing a nationwide spatial framework. This framework will support the creation of coherent land use ordinances, facilitate climate-adaptive smart growth, and promote sustainable spatial planning in times to come.

The NLUZ initiative can be considered as a key driver for sustainable development in Bhutan, guided by the country's constitutional mandate to maintain at least 60% forest cover and supported by various strategies. The existing legal and policy frameworks, such as the Land Act (2007), National Biodiversity Strategy and Action Plan (NBSAP, 2014; 2024), and others, emphasize the need for zoning to address future needs, manage natural hazards, and ensure food security. It aligns land use practices with the Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land). Moreover, poor land use has been reported by UNCCD (2018) to cost the nation 9% of its GDP, highlighting the economic consequences of inadequate land governance (RGoB, 2023).

1.2 Problem Statement

Bhutan faces significant challenges in effectively harmonizing land uses due to competing and conflicting interests among various stakeholders (RGoB, 2018). The absence of a structured NLUZ system exacerbates these issues, leading to fragmented and inefficient land use planning.

This lack of cohesion results in conflicts and mismanagement, making it difficult to manage diverse land uses in a climate-responsive manner. To address these challenges, it is crucial to develop a harmonized NLUZ system that balances competing land uses and enhances overall land management.

Additionally, the effectiveness of Bhutan's land use planning is compromised by the absence of a comprehensive national spatial code and detailed databases on land capacity and potential. This gap in spatial tools hampers the creation of an integrated platform for spatial decision-making, resulting in inefficient land use and inadequate climate-responsive governance. The current approach also fails to adequately incorporate climate considerations into zoning and planning processes, limiting the ability to enhance climate resilience and manage climate-induced risks. Developing a robust spatial code, detailed databases, and an integrated platform is essential for improving land management practices and ensuring effective climate adaptation through the NLUZ initiative. Furthermore, addressing the ad-hoc approach to land requirements and implementing a structured, systematic approach will be vital for resolving conflicts and supporting sustainable development.

1.3 Objective

The objective of this paper is to evaluate the NLUZ initiative's role in advancing climate-responsive land governance in Bhutan. It aims to assess how NLUZ integrates climate considerations into land use planning to promote sustainability, enhance resilience to climate hazards, and preserve ecosystems. The paper will detail NLUZ's approach, including the development of a cohesive national land use system, climate adaptation strategies, land use zoning, an online database, and climate-resilient ordinances. It will analyze the effectiveness of these strategies, review success models and challenges from global case studies, and provide recommendations for improving the NLUZ framework to better address climate risks and support long-term environmental stability.

2. LITERATURE REVIEW

2.1 Nation Land Use Zoning

The NLUZ involves the classification of land uses across a country into zones based on its optimal use, which could include residential, agricultural, commercial, industrial, conservation, and other designated uses. The primary goal of NLUZ is to guide sustainable land management practices, reduce land-use conflicts, and promote balanced development across regions (Lefcoe, 2004). It has been particularly effective in countries with diverse landscapes, micro climatic conditions and competing land uses. It provides a framework within which different tiers of governments and sectors can operate, ensuring that land resources are allocated efficiently and sustainably. The effectiveness of NLUZ is often linked to the robustness of its design and implementation, including the incorporation of scientific data, stakeholder input, and adaptive management practices (Berke & Godschalk, 2009).

The perspective of NLUZ differs from country to country and region to region with defined purposes. For instance in the United States, the Smart Growth movement promotes zoning practices that encourage sustainable urban development, reduce urban sprawl, and protect natural resources (Daniels, 2001). While (Albrechts, 2006) highlights that in Europe, nations like Germany and Netherlands have national land use that integrates with environment protection and for different levels of governments address specific contexts. Likewise, in Asia, countries such as Japan, for instance, categorize land into various zones with specific regulations to balance development and conservation (Sorensen, 2002). In African countries like Kenya and Rwanda, NLUZ is increasingly being recognized as a tool to manage land resources sustainably amid growing pressures from competing needs, balancing agricultural needs with environmental conservation and urban development (MINIRENA, 2010). Due to GIS technology disruptions, NLUZ becomes vibrant and enhances the accuracy and efficiency of land uses, facilitating participatory approaches and different needs (Miller, 2006; 2003). However, there are a couple of challenges, including land tenure issues, coordination challenges at different governemnt levels, and the integration of traditional land use practices with modern zoning concepts (Rakodi, 1999). According to (Deininger et al., 2012), in many developing countries, weak governance set up and limited technical capacity hinder the effective implementation of NLUZ.

In Bhutan, as the development is guided by the philosophy of Gross National Happiness (GNH), the NLUZ aims to balance economic growth with environmental sustainability, ensuring that land use decisions contribute to both national development goals and global climate commitments (RGoB, 2018).

2.2 Land Use Harmonization

According to (FAO, 2017), the goal of land use harmonization is to resolve conflicts, promote synergies, and ensure that land use decisions contribute to broader socio-economic and environmental objectives. Globally, this approach is increasingly recognized as crucial in addressing complex land-related challenges, largely diverse interests and needs.

The concept of land use harmonization is grounded in several theoretical frameworks. For instance, integrated land use management that emphasizes the importance of coordinated planning and policy integration to achieve sustainable outcomes (McNeely & Scherr, 2003); land use planning theory provides emphasizing the importance of participatory planning, stakeholder engagement, and the use of spatial data to inform decision-making (Alexander, 2012); and principles of common property and resource management, which highlights the need for coordinated governance of shared resources, particularly relevant in contexts where land use involves multiple stakeholders with competing interests (Ostrom, 1990).

Likewise, several global frameworks and initiatives support the harmonization of land use policies and practices. The SDGs provide a comprehensive framework for harmonizing land use with broader development objectives. Goals such as SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land) emphasize the need for integrated and coherent land use policies that support sustainable development (UN, 2015). The

Convention on Biological Diversity (CBD) promotes the conservation of biodiversity through the sustainable management of land and natural resources. It encourages countries to harmonize land use policies with biodiversity conservation objectives, ensuring that land use changes do not lead to habitat loss or degradation (CBD, 2010).

However, there are challenges in achieving land use harmonization, pertaining to policy fragmentation according to (Young, 2002); data and knowledge gaps that impede alignment of land use policies (GEO, 2015); inadequate institutional and governance structures hindering efforts (Larson & Soto, 2008); and difficult in careful negotiations and consensus building (Larson & Soto, 2008).

2.3 Land Use and Climate-Responsive Land Governance

Harmonizing land use, which essentially involves zoning for specific purposes, is a crucial element in achieving effective climate-responsive land governance. The process involves aligning various land use policies and practices to ensure they collectively support climate adaptation and mitigation goals. For instance, the concept of Ecosystem-Based Adaptation (EbA) is an integral to harmonizing land use practices with climate objectives, ensuring that land use decisions enhance ecosystem health while addressing climate risks (Reid et al., 2014). Likewise, as per (Lipper et al., 2014), the Climate-Smart Agriculture is a framework that aims to increase productivity while adapting to and mitigating climate change. It supports land use harmonization by encouraging practices that improve soil health, increase water efficiency, and reduce greenhouse gas emissions. Sayer et al. (2013) proposes a landscape approach to reconcile competing land uses and address climate change holistically. China's Ecological Red Line Policy designates areas of ecological significance where development is restricted, inherently from the climate responsiveness perspective. It integrates land use planning with climate objectives by protecting key ecosystems that contribute to climate adaptation and mitigation (Li et al., 2016). Germany’s approach to integrating renewable energy infrastructure into land use planning highlights the harmonization of energy and land use policies, wherein it demonstrates how coordinated policies can advance both climate goals and land use objectives (Hake et al., 2016).

3. NLUZ BASELINE REPORT 2023

The National Land Commission (NLC), in collaboration with relevant sectors and agencies, has initiated a NLUZ exercises. This effort aims to integrate spatial data and conduct analysis to delineate designated areas and land uses across Bhutan. By categorizing land based on capability and suitability, the initiative seeks to optimize the use of limited arable land, reduce competition, and prevent land use conflicts (RGoB, 2018). Ultimately, the goal is to establish harmonized land use ordinances that enhance spatially-enabled governance and decision-making processes nationwide. The National Land Use Zoning Baseline Report 2023 was published in 2023 as a first ever land use harmonization approach for Bhutan.

3.1 Methodology

3.1.1 Preparation and Strategic Alignment

Several preparatory processes were essential for undertaking the NLUZ initiative. Key initiatives included:

- The availability of comprehensive cadastral data, which was made possible by the Royal Command through the National Cadastral Resurvey Program (NCRP) and related reforms;
- The transformation of most economically active regions from a 1:50,000 scale to a 1:25,000 scale in Topographic base mapping, providing better baseline maps and inventories;
- The 2020 Land Use Land Cover (LULC) mapping conducted by the National Land Commission, which served as a precursor for NLUZ; and
- The Geo-Information (GI) Policy of Bhutan 2018 and its associated by-laws, which ensure a robust National Spatial Data Infrastructure (NSDI). This policy also empowers the Centre for Geo-Information (CGI) and its 32 member agencies under the National Land Commission Secretariat (NLCS) on geospatial growth and development.

3.1.2 Cross-Agency Collaboration

Since land management intersects with all sectors, the NLUZ initiative required broad multi-stakeholder engagement and ownership. To enhance coordination, efficiency, effectiveness, accountability and ownership, an implementation guideline was developed in 2018, outlining a three-phased implementation modalities. Building on this, the National Land Commission (NLC) developed a technical guideline to manage and implement the technical aspects of the initiatives.

Based on these two foundational guidelines, the in-house Technical Working Group (TWG), serving as the coordinating agency, initiated the Land Use Land Cover (LULC) mapping in 2020, a critical precursor to the NLUZ mapping being carried out parallelly. The program faced delays due to the COVID-19 pandemic. However, following the zoning guidelines' three-phased modalities, the in-house TWG was reconstituted and resumed the tasks, undertaking an intensive study to refine the fit-for-purpose methodology and ensure the desired zoning outcomes. Subsequently, all relevant agencies were consulted, and cross-agency TWG members from over twelve organizations were re-engaged to collaborate on initiatives under the revised scope of the NLUZ.

3.1.3 Three-Step Technical Approach

Step 1: Data Acquisition and Validation
In the NLUZ process, spatial datasets were collected from various agencies and rigorously validated, cleaned, and classified using specific geoprocessing and map analysis techniques involving the data producing agency. The validation ensures data accuracy and standardization while maintaining data ownership and minimizing alterations unless necessary for technical

alignment. Metadata documentation, adhering to ISO standards, was essential for standardizing the datasets and providing crucial information on spatial context, data quality, and integration capabilities, ensuring reliable land use visualization and analysis.

Step 2: Defining Feature Datasets and Zones
Zones for NLUZ mapping and analysis were defined based on technical definitions sourced from legal documents and credible references involving the stakeholders. This process involved establishing nine macro zones, 23 micro zones, and 23 nano zones, along with relevant Rights of Way (RoWs), land use/land cover (LULC), and demographic components. Where definitions were unavailable, the Technical Working Group (TWG) conducted studies to develop them.

Step 3: Geo-processing and Map Analysis
A centralized database was created to store and manage information from various stakeholders, facilitating efficient data integration and accessibility for map analysis. Using GIS software such as QGIS and ArcGIS, the macro zones and buffer areas were analyzed, with accuracy ensured through calculations of overlapping areas and the development of conflict matrices.

3.2 Analysis and Findings

3.2.1 Land Use Assessment

The NLUZ exercise aimed to delineate entire land uses in the country by zones through analyzing current land use patterns and integrating data from the national cadastral database for most land uses. Additional land use data were collected from relevant stakeholders, including identified and delineated High Conservation Value (HCV) data, to enhance conservation land use integration and support a harmonized decision-making process. The NLUZ baseline established nine macro land use zones, along with 23 micro zones and 23 nano zones, incorporating HCV areas as well into the land uses. Essential datasets, such as land use land cover (LULC), glacial lake inventory, topography, heritage sites (Ney Atlas), demographic information, and rights-of-way/buffer zones, were also utilized. The zoning process was conducted administratively and technically, guided by existing legal frameworks, guidelines, and a consensus-building approach amongst the sectors.

The eight macro land uses, excluding the Strategic Development Zone (SDZ), account for approximately 65.46% of Bhutan's total geographical area. Among these, the Nature Conservation Area (NCA) dominates with 79.18% of the land use, followed by the Sustainable Forest Management Area (SFMA) at 11.63%, and agricultural land at 6.59% (RGoB, 2023).

The remaining land uses each contribute between 0.50% and 1.50%, indicating a strong emphasis on conservation and agrarian land use within the country. When considering the total land area of Bhutan, the NCA and SFMA together comprise 60.85%, agriculture accounts for 4.41%, industrial land (for manufacturing, production, and services) makes up 0.11%, human

settlements (rural and urban) cover 0.76%, and other uses (including cultural and rangeland) constitute 0.88% (RGoB, 2023).

3.2.2 Land Use Conflict Assessment

The competing sectoral interests within the current decision-making system, influenced by the prevailing political, economic, and social context, are central to both perceived and actual land use conflicts. Although some sectors may experience conflicts due to the undue imposition of eminent domain, these conflicts are not inherently negative (RGoB, 2023). At the national level, land use conflicts can represent critical components of change and development. However, problems arise when mechanisms for managing and resolving conflicts fail, leading to discord at both sectoral and national levels, even costing huge for the nation and the people. An uncoordinated institutional framework and inadequate spatial governance systems can perpetuate cycles of land use conflicts and issues.

Table 1: Conflict Matrix by Individual Macro Land Use Zones (area in acres)

Macro Zones & Conflicts	Agriculture	Culture	Industrial	NCA	Rangeland	Rural Settlement	SFMA	Urban
Agriculture	**418561.253**							
Culture	314.2	**4688.512**						
Industrial	115.628	0.2	**10260.717**					
NCA	31,100.75	562.123	292.065	**5032772.23**				
Rangeland	1.366	0	0	66,821.23	**78740.372**			
Rural Settlement	0.174	156.944	13.265	5,076.57	0	**39810.305**		
SFMA	22,386.89	405.674	595.324	79,463.19	0	3,392.17	**739432.446**	
Urban	1,890.83	738.963	523.179	1,311.25	0	1,546.61	1,571.71	**31,908.85**

To better discern land use conflicts, several cases were examined during the NLUZ exercises. In the baseline, land use conflicts were most prominent in the conservation land uses. The Nature Conservation Area (NCA) including HCV, as a major zoning category, experienced the highest level of conflict at 42.29%, followed by the Sustainable Forest Management Area (SFMA) with 24.70%, and Rangeland and Agricultural zones with 15.31% and 12.78%, respectively. Of the total 6,210,176.574 acres within macro zones, 436,560.588 acres, or 6.87%, are affected by land use conflicts, excluding buffer to buffer conflicts (14,166.942 acres). Prior to the NLUZ exercises, without spatial integration and sectoral engagement, conflict areas reached 1,851,074.302 acres, or 29.12% of the total macro land uses.

As indicated in Table 1, the assessment reveals that the NCA and Agricultural Land macro zones conflict with seven other macro zones, while Industrial, SFMA, Rural Settlement, and

Culture zones conflict with six others. The NCA paired with SFMA ranks as the top macro land use conflict, followed by NCA's conflicts with rangeland and agricultural land. Regarding RoW/buffers, road RoW leads in conflict with three macro land use zones: NCA, SFMA, and Urban. Powerline RoW conflicts with SFMA, Urban, and NCA follow, with minimal conflict margins. Other RoW/buffers like flood hazard, heritage buffer, and flight funnels also present conflicts with some macro land use zones.

The conflict assessments also suggest mitigation actions, identifying specific lead and collaborating agencies responsible for addressing each land use conflict. Key triggers for these conflicts include increasing land scarcity with limited innovative solutions, weak institutional structures and governance, and the complex interactions between different land uses. In summary, allowing the current extent of land use conflicts to persist would undermine efforts toward land use harmonization, ultimately jeopardizing climate-responsive land governance initiatives in the country.

4. NLUZ FOR CLIMATE RESILIENCE LAND GOVERNANCE

From a climate-responsive land governance perspective, the NLUZ initiative turned into an instrumental in promoting sustainable land use practices that consider climate change impacts. By integrating climate considerations into land use zoning and planning, the initiative supports the preservation of critical ecosystems, enhances resilience against climate-induced hazards, and promotes the sustainable use of natural resources. This initiative and approach support not only addresses current needs but also anticipates and mitigates future climate-related challenges, contributing to the long-term sustainability and environmental stability of Bhutan.

4.1 Climate Impact Mitigation, Adaptation, Preparedness and Planning

In the context of climate impact, the NLUZ baseline initiative emphasizes the consolidation of potential hazard and risk data, such as rain-induced flood and Glacier Lake Outburst Flood (GLOF) data, from responsible agencies. This data is overlaid with critical land uses, including institutional and settlement areas, to assess risk and develop targeted mitigation strategies. Using GIS tools like ArcGIS Pro and QGIS, spatial analyses—including buffer, clip, proximity, and overlay operations—were conducted across macro, micro, and nano zones to identify overlaps, conflicts, and relevant statistics within current land use practices.

Creating precise flood risk maps is essential for informed decision-making and public awareness, aiding in the development of adaptation and mitigation strategies. For instance, overlaying flood hazard data with the macro land use zones allows policymakers to identify areas at high risk of flooding, thereby guiding strategic zoning decisions to protect critical infrastructure and settlements. This approach not only reduces potential flood damage but also supports sustainable land use practices that prioritize the protection of arable land and natural ecosystems, crucial for biodiversity and local livelihoods.

The NLUZ initiative also integrates climate adaptation considerations into its zoning process, particularly delineating NCA and SFMA amongst the zones which together cover 90.34% of

the total macro land use zones. These zones are vital for conserving biodiversity, maintaining ecosystem services like water filtration and carbon sequestration, and enhancing resilience against climate impacts. Proper delineation of Forest Management Units (FMUs) and Community Forests (CFs) further strengthen forest ecosystems, enabling them to better withstand and recover from climate-induced disturbances.

For example, buffer zones around critical water reservoirs, and core and transition zones within Nature Conservation Areas help safeguard these environments from over-exploitation. Such measures are crucial for maintaining natural processes that support ecosystem resilience and mitigate climate change effects.

The NLUZ initiative is instrumental in optimizing land use by clearly defining land use categories and addressing conflicts. Following the NLUZ baseline assessment, it has facilitated the rationalization of land releases, including necessary land substitutions and swaps prompted by climate impacts and ad-hoc demands. This innovative strategy enabled overlay analysis of requested land data from clients against zoning baseline data, allowing for a comprehensive evaluation of how different land uses can coexist while prioritizing climate resilience through the incorporation of environmental protection and disaster-related data. By utilizing these overlay analysis, it facilitates the identification of vulnerable and environmentally sensitive areas prior to land release.

This shift to a data-driven, zoning-based approach marks a significant advancement in enhancing climate resilience within land governance practices. This process helps prevent environmental degradation and supports more orderly and sustainable land management. Additionally, the initiative's geospatial coordination has provided disaster management agencies with access to a unified database of over 200 geospatial datasets. This integration enhances spatial risk assessments and preparedness efforts, streamlining planning processes, reducing costs, and improving responsiveness to climate impacts. As such, the NLUZ initiative is a cornerstone of Bhutan's strategy for climate-resilient land governance.

4.2 Success Models and Lessons for Case Evaluation

Through review and online research, it is evident that successful models worldwide have effectively integrated climate-responsive land governance into NLUZ related activities. Harmonized land use systems, like NLUZ, have been successfully implemented in various regions as part of broader climate-responsive strategies. These models and case studies demonstrate how integrated land use planning can promote sustainable development, enhance climate resilience, and support environmental conservation, as illustrated in Table 2.

Table 2: Forms of NLUZ success cases implemented

Country	Models	Climate Responsiveness	Application to Context
Rwanda	Land Use Consolidation Program	Promotes sustainable agricultural practices and improved land productivity (FAO, 2017).	Similar adoption considering climate-vulnerable position.

Costa Rica	PES Program	Encourages the conservation, climate regulation and carbon storage (McNeely et. al, 2003)	Enhance similar incentive-based mechanisms within its NLUZ framework.
Netherlands	Delta Program	Integrates land use zoning with climate adaptation measures, (GEO, 2015).	Complete climate adaptation strategy incorporations.
Brazil	The Amazon ARPA Program	Mitigating climate change by preserving the Amazon's vast carbon stocks (Sayer, 2013).	Collaboration for clear zoning for conservation to meet its commitments
Australia	Northern Territory's Land Use Planning Framework	Incorporates climate adaptation strategies, such as managing land use in flood-prone areas, and promoting sustainable agriculture (Daniels, 2001).	Continue efforts for geospatial consolidation and collaboration to ensure seamless NSDI in Bhutan.
Philippines	Philippines: CLUP	Incorporates climate adaptation and sustainable agricultural practices (Reid, 2014).	Incorporation of similar practices under NLUZ.

The successful models and case studies of harmonized land use systems around the world offer substantive validation for NLUZ (Albrechts, 2006; Alexander, 2012; CBD, 2010) as well as valuable lessons for Bhutan as it undertakes its NLUZ initiative as indicated in the Table 2.

5. ISSUES AND CHALLENGES

The National Land Use Zoning (NLUZ) initiative in Bhutan faces several challenges that hinder its effectiveness in promoting climate-responsive land governance. These limitations include the quality of spatial data from various sectors, the absence of ground-level delineation of zones on cadastre basis, insufficient integration of spatial sensitivity in decision-making processes, and the limited efficiency of geospatial institutions. To address these issues and enhance the NLUZ as a cohesive approach for climate-responsive land governance, it is essential to address challenges related to data quality, technological capabilities, and governance structures.

5.1 Data

The absence of detailed and large-scale, settlement-based data on disasters significantly impairs the implementation of effective climate adaptation strategies. Accurate data is essential for identifying vulnerable areas and populations, and without it, communities may remain unaware of their exposure to climate hazards. This lack of awareness increases their vulnerability and the risk of displacement during extreme weather events. Additionally, the inconsistency in land use data, such as discrepancies between FAO/World Bank reports and NLUZ data, undermines effective land management (RGoB, 2023). The absence of critical datasets, including comprehensive watershed and spatial data on soil, further hampers the ability to assess land use

suitability and capabilities. Furthermore, fragmented and inadequate data repositories complicate the understanding of land use patterns and tenure rights, making it difficult to create a cohesive land management strategy.

5.2 Technology

Technological challenges primarily revolve around issues with data system integration and the standardized method of data acquisition. The lack of a unified data platform has led to inconsistencies and discrepancies in land use data, hindering the effective management and dissemination of accurate information. The process of reclassifying and validating spatial data is complicated by outdated satellite imagery and incomplete ground truthing, which can lead to inaccuracies in land use zoning maps. Furthermore, the varied data acquisition methods, such as handheld GPS and satellite imagery in conservation and management areas, instill differences in accuracy and precision, affecting the reliability of land use data. Map scaling and base data usage also pose problems; different scales and data sources can reduce the accuracy of zoning maps, especially when inconsistent data is used across various scales.

5.3 Governance

Governance issues are evident in several areas, affecting the overall effectiveness of land use management. Delays in implementing updated urban boundaries and discrepancies between defined and tax-related boundaries have hindered comprehensive urban zoning efforts. The Protection of Agricultural Land (PAL) is compromised by inadequate field validation and insufficient government support, which impacts land use planning and food security intentions. Community land use validation is also needed to confirm the actual uses of registered community lands, as some are currently utilized for residential and institutional purposes. Nonconforming land uses, such as commercial use of plots designated for CSOs, further complicate land management. Misclassification of residential plots as religious institutions and the irrational acquisition of land for institutional purposes lead to economic losses and inaccuracies in land use data. Additionally, inconsistencies in mining records require collaborative efforts for accurate mapping. Addressing these governance challenges is crucial for ensuring that land use planning and management are effective and aligned with both environmental and community needs.

6. STRATEGIC RECOMMENDATIONS

Based on the insights gained from successful models of harmonized land use systems globally, here are strategic recommendations for Bhutan’s NLUZ initiative, categorized into three key areas: harmonizing strategies, climate-responsive framework, and future research.

6.1 Harmonization Strategies

i. Continued efforts in harmonized land use zoning is critical for integrating various land uses in a timely manner aligning with national priorities. This can reduce land use conflicts, improve data accuracy, and streamline decision-making across sectors.

ii. Refining and incorporating climate considerations into land use zoning is essential for better mitigating climate risks and adapting to changing environmental conditions. Zoning based on climate risk assessments and conservation priorities enhances resilience and contributes to sustainable development.

iii. Cross-agency collaboration and stakeholder engagement need to be continued to ensure that zoning is inclusive, widely supported, and effectively implemented. This must be able to guide land management practices with climate goals and involving all relevant stakeholders, which can create a resilient, sustainable, and adaptive land use framework that meets both environmental and socio-economic needs.

iv. Adopt an integrated land use planning framework that integrates land parcels to reduce fragmentation, particularly in agricultural zones. This can improve land productivity and ensure that land use aligns with national priorities.

v. Introduce financial incentives and subsidies for landowners who engage in sustainable practices, such as reforestation, organic farming, and conservation efforts in overall payment for ecosystem service intervention. This will align economic benefits with sustainable land use, encouraging landowners to adopt practices that support national and environmental goals.

vi. Implement Spatial Decision Support Systems (SDSS) that integrate entire land uses, including climate data. This ensures predictive models that help policymakers make informed decisions about land release, use and development under different climate scenarios. This shall foster a centralized geospatial data repository that harmonizes data from various sectors, including agriculture, forestry, urban development, and conservation. This will reduce duplication, improve data accuracy, and facilitate coordinated land use planning across different governmental departments.

6.2 Climate-Responsive Framework

i. Recommends to comprehensively incorporate climate risk assessments into the zoning process by identifying and designating zones based on their vulnerability to climate change impacts such as floods, landslides, and GLOFs. These zones should prioritize climate adaptation and disaster risk reduction strategies; and

ii. Adaptive and dynamic land use planning is recommended to regularly update zoning maps to reflect changing climate conditions and emerging environmental data. This adaptive approach will ensure that land use planning remains relevant and responsive to the evolving climate landscape. For instance, the delineation of unzoned areas and the rationalization of agricultural land must be informed by an understanding of how climate change will alter land productivity, water availability, and ecological balances. As climate patterns shift, so too must the zoning and management strategies, which means that the NLUZ needs to be a living document, continually updated with new data and insights.

6.3 Future Research

i. Nationwide impact assessment studies in the form of longitudinal studies to evaluate how harmonized land use systems influence climate resilience over time. This research should focus on tracking changes in ecosystem health, biodiversity, and local climate patterns as a result of integrated land management practices; and

ii. Recommended to develop advanced models to assess how harmonized land use zoning reduces vulnerability to climate change. Research should examine how zoning can minimize the impact of extreme weather events quantitatively and qualitatively, such as floods and droughts, on both natural and human systems.

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BIOGRAPHICAL NOTES

Gonpo Tenzin, Chief Planning Officer in the land sector for the past eight years, has coordinated National Land Use Zoning, Geo-Information Policy, and the drafting of the National Land Policy. He previously held roles as Deputy Chief Research Officer at the Gross National Happiness Commission, Deputy Program Director in the Royal Office, and District Planning Officer. He also served as a focal point for environment, trade, and gender. He is the recipient of '2016 Award for Planning Excellence' from the Australian Capital Territory, Australia.

Chencho Tshering, a Survey Engineer with the Geo-Informatics Division since January 2022, graduated in GIS and Remote Sensing from Amity University in 2021. He began his career developing Druk OneMap in collaboration with the University of Twente, Netherlands, and has since contributed to various mapping projects and the National Spatial Data Infrastructure as a technical working member.

Pema Wangda, a GIS Officer with six years of service under Samdrup Jongkhar Municipality and the National Land Commission, played a key role in the National Spatial Data Infrastructure and National Land Use Zoning Project. He also led the development of Samdrup Jongkhar's Geodatabase and was named Outstanding Employee of the Year for 2023 and 2024.

Tika Chhetri, a Licensed Surveyor with 13 years at the National Land Commission Secretariat, has played a key role in Bhutan's National Cadastral Resurveying Program. He has expertise in various surveying disciplines and has supported national events like the Snowman Race and COVID-19 efforts with geospatial mapping. Passionate about training, he has educated non-GIS professionals across sectors. Currently, he focuses on cartography, geospatial analysis, web-based GIS, and the NLUZ Project.

CONTACTS

Gonpo Tenzin
National Land Commission
203 Drophen Zur Lam 15 Northwest
Thimphu
Bhutan
Tel. +975-17111666
Email: gnhbhutan@ gmail.com
Web site: web.nlcs.gov.bt