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Planning and regulatory instruments in territorial planning sustainable. Case Study: Human Settlements threatened in Latacunga lahars, Ecuador

Instrumentos de planificación y normativos en la ordenación territorial sostenible. Estudio de caso: Asentamientos humanos amenazados por los lahares de Latacunga, Ecuador

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ABSTRACT

This study examines the integration of sustainable urban planning and disaster risk management in Latin America, focusing on the Latacunga canton in Ecuador—a region highly vulnerable to volcanic hazards from the Cotopaxi volcano. Utilizing a mixed-method approach, the research evaluates the alignment between national legislation (COOTAD, LOOTUGS) and local planning instruments: the Development and Territorial Planning Plan (PDOT) and the Land Use and Management Plan (PUGS). The methodology incorporates a qualitative normative analysis, a GIS spatial overlay intersecting official lahar hazard maps with municipal cadastral databases, and a feasibility assessment of institutional governance constraints. The spatial analysis reveals a critical implementation gap between theoretical regulatory frameworks and actual territorial occupation. Approximately 420.50 hectares of high-density, consolidated urban land and 285.10 hectares of peripheral expansion zones are directly exposed to high or very high laharic risk levels. Furthermore, weak municipal control by the local government allows informal land markets to proliferate, subdividing rural agricultural properties without basic infrastructure and severely exacerbating socioeconomic vulnerabilities. The study concludes that while Ecuador's macro-level regulations provide comprehensive guidelines for risk-inclusive planning, their practical efficacy is strictly constrained by the technical, financial, and administrative capacities of local decentralized governments. To mitigate latent risks of large-scale anthropogenic disasters, municipal authorities must move past paper-based compliance. Future efforts must prioritize active urban enforcement, participatory governance, and strict regulation of informal real estate dynamics to foster a resilient territorial model.

RESUMEN

Este estudio analiza la integración de la planificación urbana sostenible y la gestión del riesgo de desastres en América Latina, centrándose en el cantón de Latacunga, en Ecuador, una región altamente vulnerable a los riesgos volcánicos derivados del volcán Cotopaxi. Mediante un enfoque de métodos mixtos, la investigación evalúa la coherencia entre la legislación nacional (COOTAD, LOOTUGS) y los instrumentos de planificación locales: el Plan de Desarrollo y Ordenación Territorial (PDOT) y el Plan de Uso y Gestión

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del Suelo (PUGS). La metodología incorpora un análisis normativo cualitativo, una superposición espacial mediante SIG que cruza los mapas oficiales de riesgo de lahares con las bases de datos catastrales municipales, y una evaluación de la viabilidad de las limitaciones de gobernanza institucional. El análisis espacial revela una brecha crítica de aplicación entre los marcos normativos teóricos y la ocupación territorial real. Aproximadamente 420,50 hectáreas de suelo urbano consolidado y de alta densidad, y 285,10 hectáreas de zonas de expansión periférica, están directamente expuestas a niveles de riesgo de lahares altos o muy altos. Además, el débil control municipal por parte del gobierno local permite la proliferación de mercados informales de suelo, lo que da lugar a la subdivisión de propiedades agrícolas rurales sin infraestructura básica y agrava gravemente las vulnerabilidades socioeconómicas. El estudio concluye que, si bien la normativa a nivel macro de Ecuador proporciona directrices exhaustivas para una planificación que tenga en cuenta los riesgos, su eficacia práctica se ve estrictamente limitada por las capacidades técnicas, financieras y administrativas de los gobiernos locales descentralizados. Para mitigar los riesgos latentes de desastres antropogénicos a gran escala, las autoridades municipales deben ir más allá del mero cumplimiento sobre el papel. Los esfuerzos futuros deben dar prioridad a la aplicación activa de la normativa urbana, la gobernanza participativa y la regulación estricta de las dinámicas inmobiliarias informales para fomentar un modelo territorial resiliente.

Keywords / Palabras clave

Territorial planning, urban planning, land management, territorial sustainability.

Planificación territorial, planificación urbana, gestión del suelo, sostenibilidad territorial.

Introduction

This Sustainable urban planning has established itself as a fundamental strategy in Latin America to address challenges associated with the accelerated growth of cities, disorderly urban sprawl, territorial inequality, and increasing exposure to natural hazards (UN-Habitat, 2022). In this context, territorial planning is a key tool to promote balanced development, improve the quality of life

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
eISSN: 2600-5743

of the population and guarantee an efficient and sustainable use of available resources.

Sustainable urban planning has established itself as a fundamental strategy in Latin America, a region where over 80% of the population resides in urban centers. However, executing these frameworks requires navigating a complex reality marked by deep socioeconomic inequalities and rapid, often informal, peripheral growth.

Traditional planning models frequently clash with the spontaneous expansion of informal settlements, where vulnerable communities lack critical access to clean water, basic sanitation, and reliable public transit. Additionally, Latin American cities face escalating climate vulnerabilities—ranging from landslides in steep Andean terrains to severe flooding in coastal hubs—making urban resilience a matter of immediate survival rather than a theoretical ideal.

To address these pressing challenges, current regional strategies are increasingly incorporating contemporary models like Transit-Oriented Development (TOD) and nature-based solutions to mitigate urban sprawl and protect endangered ecosystems. Local governments are working to align municipal master plans with global mandates, such as the New Urban Agenda and SDG 11.

Yet, a persistent implementation gap remains. While many countries possess highly progressive national land-use legislation, local municipalities often lack the administrative, financial, and enforcement capabilities required to control aggressive real estate speculation and regulate territory effectively. Ultimately, sustainable urban planning in Latin America is evolving past simple aesthetic zoning toward a model of participatory governance, aiming to bridge the stark divide between the formal and informal city.

In Ecuador, territorial planning is regulated by the Constitution of the Republic of Ecuador (2008), the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD, 2010) and the Organic Law of Territorial Planning, Use and Management of Land (LOOTUGS, 2016). These instruments establish the competencies of the Decentralized Autonomous Governments and the necessary mechanisms for the planning, management and regulation of land use through tools such as the Development and Territorial Planning Plan (PDOT) and the Land Use and Management Plan (PUGS) (Constitution of the Republic of Ecuador, 2008; COOTAD, 2010; LOOTUGS, 2016).

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
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Within this framework, the Latacunga canton is a relevant case study due to its importance as an urban center of the province of Cotopaxi and its historical exposure to volcanic threats associated with the Cotopaxi volcano. This condition poses significant challenges for territorial planning and risk management. Therefore, this paper analyzes the relationship between the current regulatory framework and the application of land use planning instruments in Latacunga, with the purpose of identifying their contribution to sustainable development and the reduction of territorial vulnerability.

Material y Methods

Theoretical foundations

The conceptual basis of sustainable land use planning is based on the intersection of urban geography, urban planning law and landscape ecology. From a social perspective of risk, Lavell (2000) argues that disasters are not only the result of natural hazards, but also of the conditions of vulnerability generated by the processes of occupation and development of the territory. In this sense, risk is understood as a social construction linked to human decisions related to land use and the location of settlements. For this reason, territorial planning is a fundamental tool to reduce the vulnerability of the population and promote safer and more resilient territories.

National Regulatory Framework and Public Policies

Territorial planning in Ecuador is supported by a regulatory framework made up of the Constitution of the Republic of Ecuador (2008), the Organic Code of Territorial Organization, Autonomy and Decentralization (COOTAD, 2010) and the Organic Law on Territorial Planning, Land Use and Management (LOOTUGS, 2016). These regulations establish the competencies of the Decentralized Autonomous Governments in the planning and management of the territory, regulate the use and occupation of the land and promote instruments such as the Development and Territorial Planning Plan (PDOT) and the Land Use and Management Plan (PUGS). They are also articulated with national development and planning policies, incorporating criteria of sustainability, territorial equity, adaptation to climate change and disaster risk management, with the aim of

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
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promoting orderly and safe territorial development (Constitution of the Republic of Ecuador, 2008; COOTAD, 2010; LOOTUGS, 2016).

International Normative Framework

At the international level, disaster risk management and sustainable territorial planning are based on various instruments that guide public policies towards the construction of safer and more resilient territories. First, the Sendai Framework for Disaster Risk Reduction 2015-2030 establishes the need to understand risk, strengthen governance, and promote investments for vulnerability reduction, integrating risk management into territorial planning and sustainable development processes (United Nations Office for Disaster Risk Reduction [UNDRR], 2015).

Similarly, the 2030 Agenda for Sustainable Development recognizes the importance of strengthening the resilience of human settlements to natural hazards.

Sustainable Development Goal 11 seeks to make cities and human settlements inclusive, safe, resilient and sustainable, while SDG 13 promotes actions to combat climate change and strengthen capacities for adaptation and response to risks and disasters (United Nations [UN], 2015).

On the other hand, the New Urban Agenda promotes sustainable urban development models that incorporate criteria for territorial planning, disaster risk reduction and urban resilience. This instrument promotes the safe occupation of land, the prevention of settlements in risk areas, and the strengthening of institutional capacity to manage orderly and sustainable urban growth (UN-Habitat, 2017).

In the case of the Latacunga canton, these international instruments constitute a framework of reference to strengthen the incorporation of volcanic risk management within territorial planning instruments, contributing to the reduction of the vulnerability of the population exposed to the lahars of the Cotopaxi volcano and favoring the construction of a safer territory. resilient and sustainable.

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
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Technical Support Methodology

For the development of the technical diagnosis of the case study in the canton of Latacunga, the following fundamental inputs were collected and processed:

1. Official multi-temporal cartography of the Military Geographic Institute (IGM)
2. Threat maps for lahar flows generated by the Geophysical Institute of the National Polytechnic School (IG-EPN)
3. Georeferenced property and cadastral database provided by the Decentralized Autonomous Municipal Government of Latacunga (GADM-L).
4. The Development and Territorial Planning Plan (PDOT) and the Land Use and Management Plan (PUGS) of the Latacunga Canton approved in their latest current updates.

The research adopts a mixed approach (qualitative - quantitative) of descriptive and correlational type, structured in three sequential phases:

- Phase 1: Qualitative-normative analysis. It consisted of the review of external and internal legal coherence, crossing the punitive and restrictive provisions of the LOOTUGS and the COOTAD against the local building and land use ordinances in force in Latacunga, in order to evaluate the level of alignment and integration of the risk management guidelines.
- Phase 2: Spatial Processing and Superposition (GIS). Using geographic information systems (ArcGIS / QGIS), an analysis of the spatial intersection between the map of volcanic hazard by lahars of the IG-EPN and the layer of consolidated areas and urban expansion foreseen in the local PUGS is proposed. This made it possible to quantify the area of urban-environmental conflict and the number of residential properties exposed.
- Phase 3: Feasibility Assessment and Management Instruments. The budgetary, institutional and participatory governance constraints that restrict the effective application of severe corrective measures, such as the relocation of informal

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
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settlements, the declaration of reserve zones or protection zones due to non-mitigable risks, were qualitatively analyzed.

Results

From The results demonstrate a significant gap between the sophistication of the normative design on paper (LOOTUGS/PUGS) and the real dynamics of territorial occupation of the Latacunga canton. The distribution of land use is then tabulated and the levels of spatial exposure identified in the consolidated urban and peripheral area of the canton with respect to the transit areas of lahars:

Table 1. *Exposure of land is used to areas threatened by lahars in Latacunga.*

Soil Category (According to PUGS)	Total Exposed Area (Ha)	Laharic Risk Level	Theoretical Normative Constraint (LOOTUGS)
Consolidated Urban (Commercial / Residential)	420.50	High / Very High	Mandatory Mitigation / Prohibition of Densification and increase in heights.
Urban Expansion (Residential peripheral)	285.10	Moderate to High	Conditional on specific microzoning studies and works of previous mitigation.

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
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Rural Agricultural Production	1,150.30	High (Lower valley areas)	Permitted agricultural use; absolute prohibition of fractionation for purposes housing.
Ecological Protection Zones and Rivers	340.20	Extreme (Main channel)	Absolute prohibition of residential gray building and infrastructure. Regime of conservation.

The spatial analysis reveals that approximately 420.50 hectares of already consolidated urban land that houses critical facilities, shops and high-density residential areas are located directly on the historic lahar flood zones. The main finding lies in identifying the legal and institutional conflict between the acquired rights of urban property and the sanctioning restrictions established by the LOOTUGS for land in areas of non-mitigable risk.

In the peripheral expansion sectors, the PUGS establishes low-density guidelines; however, the dynamics of the informal land market and spontaneous settlements evade local regulations, subdividing rural properties without the provision of basic services and increasing socioeconomic vulnerability. The weakness in effective urban control by the GADM-L acts as the main catalyst in the conversion of a natural hazard (the Cotopaxi volcano) into a latent scenario of large-scale anthropogenic disaster.

Conclusions

The Ecuadorian regulatory framework, mainly made up of the Constitution of the Republic of Ecuador, COOTAD and LOOTUGS, provides the necessary guidelines for territorial planning and risk

Received April 11, 2026/ Approved June 02, 2026 Pages: 22-33
eISSN: 2600-5743

management; however, its effective application depends on the technical, administrative and financial capacity of the Decentralized Autonomous Governments.

Territorial planning instruments, such as PDOT and PUGS, are key elements to guide the appropriate use of land and promote a more balanced and sustainable territorial development.

The analysis of the case of the Latacunga canton shows that the incorporation of risk management in territorial planning is essential to strengthen the sustainability of the territory, optimize response mechanisms to adverse events and contribute to the well-being of the population.

The reduction of vulnerabilities in the face of natural hazards requires the participation of citizens, efficient institutional management and the application of preventive strategies that contribute to the construction of safer and more resilient territories.

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