

SUSTAINABLE URBAN MOBILITY AND LANDSCAPE CONSERVATION: THE CASE OF BELLA DURMIENTE HILL IN LIMA, PERU ¹

MOVILIDAD URBANA SOSTENIBLE Y CONSERVACIÓN PAISAJÍSTICA: EL CASO DE LA
LOMA LA BELLA DURMIENTE EN LIMA, PERÚ

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Las áreas paisajísticas de Lima se encuentran en peligro de desaparición debido a la expansión de la ciudad. Dentro de estas áreas se ubican las lomas costeras, que crecen en diversos distritos de la ciudad debido a la neblina. Uno de esos distritos es Independencia, en Lima Norte, en donde se hallan diversas lomas, y una de estas es la Loma Bella Durmiente, que en parte de su extensión conserva su belleza paisajística y biodiversidad, y aún no es invadida. Por ello, el artículo analiza las estrategias de movilidad urbana para la conservación de la loma. La metodología utilizada se basa en la observación participante y en el método cartográfico para recopilar información in situ y procesarla en el gabinete. Entre los principales resultados, relacionados con la movilidad urbana, se destaca la existencia de distintas escalas de acceso a la loma, la metropolitana, la distrital y la barrial, condicionadas por la geografía del distrito. Asimismo, se identificaron iniciativas de protección de la loma impulsadas por los vecinos de los barrios en ladera. Sin embargo, se ha evidenciado una falta de planificación que considere estas particularidades para hacer el recorrido más amigable y atractivo.

Palabras clave: conservación de áreas paisajísticas, lomas, movilidad urbana sostenible

Lima's landscaped areas are in danger of disappearing due to the city's expansion. These areas include coastal hills, whose vegetation emerges in various districts of the city due to the fog. One such district is Independencia, in North Lima, where several hills are located, including Loma Bella Durmiente or Bella Dumiente Hill, which retains its scenic beauty and biodiversity in part of its still-uninvaded area. This article looks to analyze urban mobility strategies for hill conservation. The methodology is based on participant observation and cartographic methods for collecting information in the field and processing it in the office. Among the main results regarding urban mobility is the existence of different access scales to the hill: metropolitan, district, and neighborhood, determined by the district's geography. Hill protection initiatives led by residents of the hillside neighborhoods were also identified. However, a lack of planning was evident, as these aspects were not considered to make the route user-friendly and more attractive.

Keywords: landscape conservation, hills, sustainable urban mobility

I. INTRODUCTION

Lima's hills are unique ecosystems in the arid regions of the Peruvian coast (Figure 1), characterized by high biodiversity driven by seasonal fog. This ecosystem faces threats due to uncontrolled urban expansion and pollution. These factors affect biodiversity and the role the hills play as green spaces that mitigate climate change and conserve water resources. (Nieuwland & Mamani, 2017). The State institutions have rules that regulate land use and protect green areas. However, these are insufficient to include these areas within the city, where land demand is very high (García et al., 2014), or to incorporate initiatives from adjoining neighborhoods that work on local alternatives directly connected to these spaces. Therefore, it is essential to analyze the condition of urban hills at metropolitan and local scales to demonstrate how they actually connect with the urban fabric. In this sense, a little-explored aspect is the role of sustainable urban mobility in conserving these landscapes.

Among the districts with hills is Independencia, home to Sleeping Beauty Hill or *La Loma La Bella Durmiente*, a self-managed ecotourism area shaped like a sleeping woman. Currently, this area is managed by residents of the surrounding neighborhoods, with some support from the State for the dissemination, promotion, and technical support of non-governmental organizations. Independencia also has a varied transport infrastructure, such as the Metropolitan bus network and private company buses on Av. Tupac Amaru and Panamericana Norte. The incorporation of Lima Metro's line 3 is also planned. According to the Transport Oriented Development theory (Rodríguez, 2021), these conditions should encourage the formation of areas around public transport stations that are well connected to the rest of the city. Within this framework, the hill should be included within these areas to guarantee its urban integration and promote its use and conservation.

Sustainable urban mobility directly influences the conservation of urban landscape areas, as in the case of Lima's hills. The conditions of accessibility to these areas are decisive in making them attractive spaces for the general public, so that they can be integrated into citizens' routines and collective memory. The connection between the nearby mass transit stations and the scenic area requires strategies that consider the development of both metropolitan and local uses. These local strategies should consider the physical articulation and integration of the population of neighboring neighborhoods, who play a key role in the co-management, maintenance, and protection of these areas.

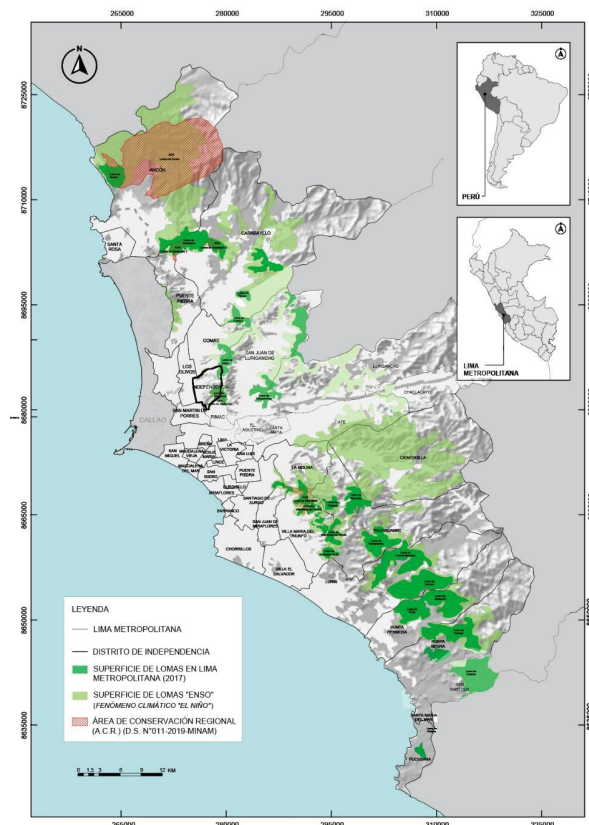


Figure 1. Lima's Hills - representative ecosystems of the city. Source: Ministry of the Environment (MINAM) and National Environmental Information System (SINIA) (2021).

In this context, this article aims to analyze urban mobility strategies to preserve the landscape of Bella Durmiente Hill. To do this, 3 specific objectives are proposed: 1) To analyze the accessibility conditions towards the Hill from a metropolitan and local perspective, 2) To examine the types of spaces and uses that accompany the route to the Hill from the nearest mass transit stations, and 3) To identify local initiatives aimed at the conservation of the Hill's landscape area.

II. THEORETICAL FRAMEWORK

An attempt has been made for more than a century, to incorporate the concept of a city with green areas into the world (Taylor, 2025), since these areas mitigate air pollution, regulate heat and noise; regulate the climate, conserve biodiversity, provide key ecosystem services, and provide opportunities for physical activity and social interaction (Rasidi et al., 2018), which has an impact on physical, mental health and social well-being. (Nieuwenhuijsen et al., 2022).

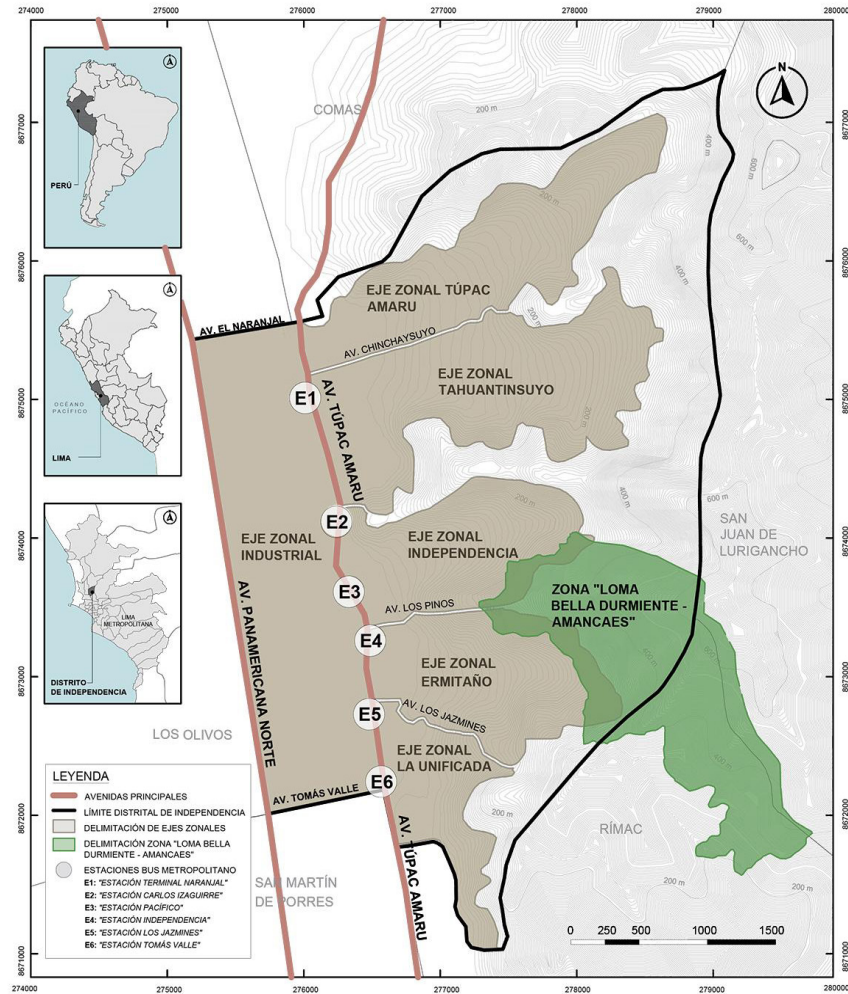


Figure 2. Independencia, the lower slope (industrial area), and hillside neighborhoods (other areas). The Hill, Tupac Amaru Ave., Panamericana Ave., and the Metropolitan stations (TOD nodes). Source: Preparation by the authors based on the land registry plan.

According to the biophilia theory, humans need to be in harmony with the natural environment to generate physical and psychological benefits (Orellana-Alvear et al., 2017), since an affective connection with nature is formed through sensory and cognitive experiences. Ecological patterns evoke security and belonging. In the urban context, these principles make it possible to understand green areas as essential spaces for health, resilience, and the construction of sustainable socio-ecological links.

However, there are problems in their management and implementation (Zuniga-Teran et al., 2021). Urban plans often fail to incorporate dimensions of access to green spaces across urban scales, limiting their effectiveness as ecological and social infrastructure (Nguyen et al., 2021). Hence, public policies must combine environmental justice, ecological

planning, and participatory governance (Hanna & Comín, 2021; Abramo, 2007). Similarly, several authors consider that participation, appropriation, and/or use are necessary for the conservation of green areas (Jacobs, 1961; Seisdedos, 2007).

Despite the ecological and social value of urban ecosystems, few studies link sustainable urban mobility to the conservation of landscape areas, particularly from a multi-scalar perspective (Vilanova et al., 2024). Urban mobility is a central concept in building sustainable cities and improving citizens' quality of life. Its study allows evaluating how transport policies can serve as a basis for efficient and environmentally friendly urban development (Tanikawa-Obregón & Paz-Gómez, 2022). Sustainable urban mobility promotes the use of public transport, bicycles, and walking (Álvarez Vanegas, 2020). Currently, there are several plans and initiatives in Lima aimed

at improving the city's mobility to make it more sustainable, but they are insufficient or have not yet been implemented. (Vega Centeno et al., 2022). On the other hand, the peripheral districts of Lima, such as Independencia, face physical (slopes, distances) and social (insecurity) obstacles that hinder the use of active modes of transport, such as walking or cycling. Despite this, residents generate local displacement dynamics to solve everyday issues (Robert & Pereyra, 2024). This situation directly affects travel times, accessibility, and residents' daily mobility experience (Ponce et al., 2022).

In that sense, the Transport-Oriented Development (TOD) model offers a useful framework for addressing the relationship between mobility and landscape. This approach promotes sustainable urban development by integrating public transport, density, compactness, multimodality, and mixed uses in a nearby area that is easily walkable and cyclable (Rodríguez, 2021). In the case of Independencia, a significant change is evident following the implementation of the metropolitan bus system and the incorporation of metropolitan-scale uses, indicating that the TOD approach should be considered to better plan the district (Figure 2). In metropolitan contexts with nearby ecosystems, TOD takes on an ecological dimension by channeling urban flows and reducing pressure on natural landscapes. By promoting sustainable transport corridors, it helps minimize local fragmentation, strengthen ecological edges, and align urban accessibility with landscape conservation, thereby integrating urban planning objectives, efficient mobility, and environmental resilience.

III. CASE STUDY

La Loma Bella Durmiente

The La Bella Durmiente Hill is located in the district of Independencia, north of Lima. The hill is a fragile, intangible ecosystem of heritage interest and landscape protection, characterized by its biodiversity, natural landscape, cultural importance, and role in environmental regulation (Nieuwland & Mamani, 2017; Sánchez, 2022), and it is part of the Lomas de Amancaes and the Lomas de Lima System. The hills represent one of the few natural spaces still preserved in the district, but they are at risk of disappearing due to urban expansion (Reaño Torres, 2022).

IV. METHODOLOGY

The work was carried out onsite and in the office, where the general and specific literature on sustainable urban mobility and TOD was reviewed. To address the three

objectives, the participant observation mechanism and analysis of printed plans were used in the field, employing the cartographic method to cover routes near the hill and develop urban layouts that facilitate understanding the current urban mobility dynamics along these routes (Figure 3). The information was then processed in the office using the accessibility, uses, spaces, and neighborhood participation variables.

To address the first and second objectives, four metropolitan bus stations were used as TOD nodes, starting from their bus stops: Naranjal, Pacífico, Independencia, and Tomás Valle (Figures 4 and 5), following the routes that visitors publish on social networks. Printed land registry plans obtained from State webpages were used to survey uses. Photos and videos of the routes from the four metropolitan transport stations to the hill were taken to identify uses, types of spaces, and forms of accessibility (means of transport and road conditions). The Moovit application was then used to identify transport lines in the district, and the Adidas Runtastic application was used to estimate distances. To review the third objective, eight face-to-face interviews, organized thematically (activities, care, and management), were conducted onsite with residents from hillside neighborhoods, while public social media content about the hill was reviewed in the office. With all this information, strategies promoting sustainable urban mobility for the hill's conservation were analyzed.

V. RESULTS

Accessibility to the Hill at a metropolitan and local level

The hill stands out in North Lima because it has 6 stations on the metropolitan bus system (Figure 4) and is within 2.5 km of the bus stops of more than 20 private bus lines. This makes the hill accessible at the metropolitan level to local residents and to residents of neighboring and distant districts. However, it appears that the State has not established mechanisms to connect the hill to the bus stations. In their absence, Independencia's resident population has created local mechanisms that link stations to the Hill through micro-mobility and pedestrian movement.

Access to the hill is multimodal due to the blocks' morphology and the district's topography. Near the initial bus stops, people move around on public buses, private buses, vans, cars, motorcycle taxis, and on foot. In the intermediate hillside neighborhoods, people use vans, cars, motorcycle taxis, and walk. In the neighborhoods on the upper slopes, people get around on motorcycle taxis and on foot. The hill, however, can only be accessed on foot. This means that two or three modes of transport must be used. It should be noted that transportation within the neighborhoods on the slopes is provided by neighbors in the same district.

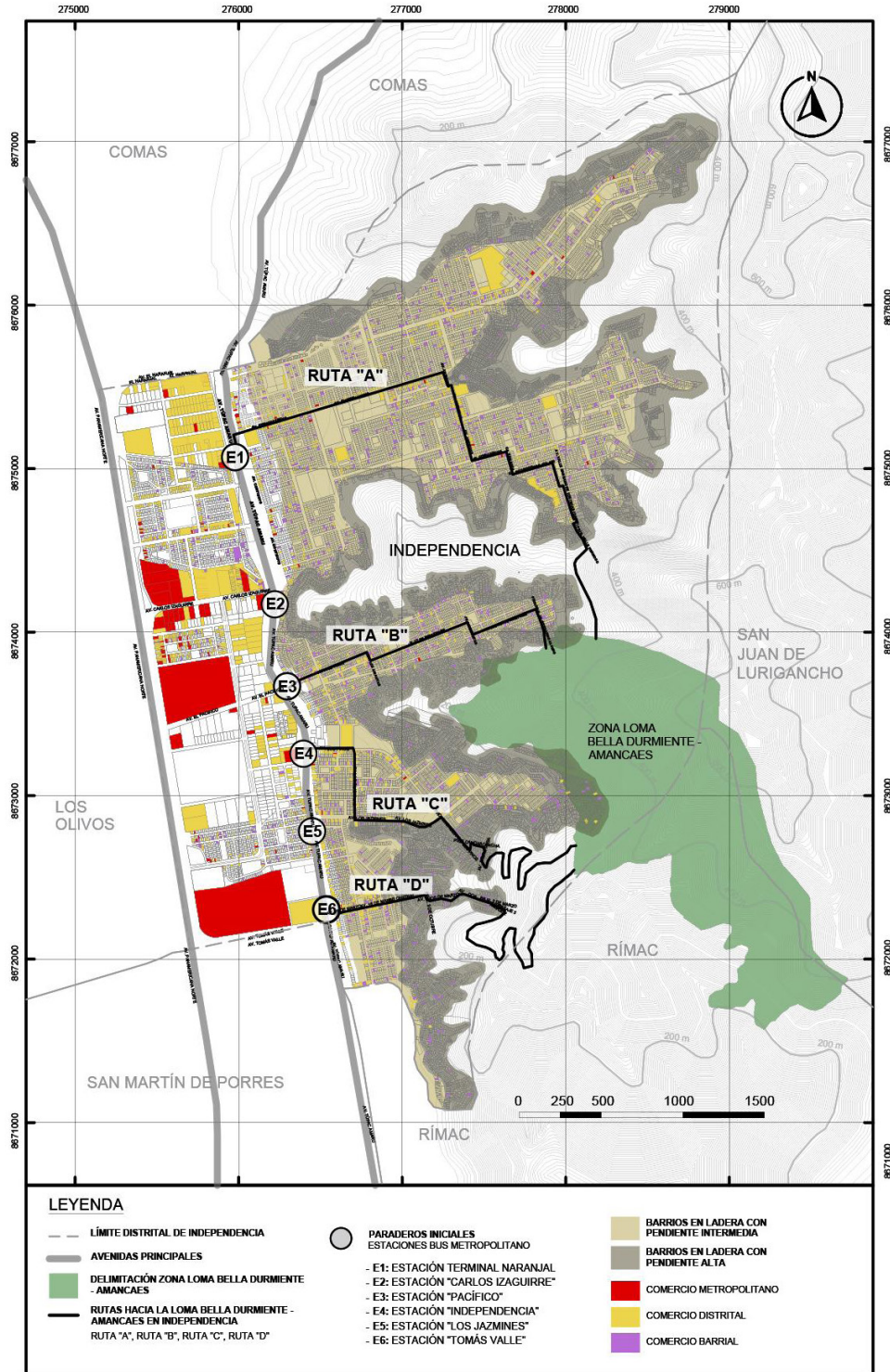


Figure 3. Routes to the hill from the Metropolitan stations (TOD nodes). Spaces and variable uses until one reaches the hill. Source: Preparation by the authors based on the land registry plan.





Figure 6. Sectors from the initial bus stops to the hill. Source: Images of the authors.

At the metropolitan level, accessibility is primarily along Túpac Amaru Ave. and the Panamericana Norte. On Tupac Amaru Ave., the metropolitan bus stations are potential TOD nodes. However, they function only as transport terminals, lacking direct connections to nearby urban spaces, such as urban landscape areas. This evidences a strategic opportunity to link mass transport with urban green infrastructure.

At the local level, there are three sections on the route between the Metropolitan and the hill's stations (Figure 6). The neighborhoods on an intermediate slope are more consolidated, with narrow sidewalks, unsafe pedestrian crossings, and no bike paths. The neighborhoods on the upper slopes are less consolidated, with no hierarchical design that facilitates movement towards the hill. Finally, the hill has informal paths, with steep slopes and a lack of signage or street furniture. This situation outlines an opportunity to improve local access to the hill, considering the existing dynamics (Table 1).

Although the metropolitan infrastructure offers highly accessible nodes, the lack of a modal hierarchy and suitable

urban transitions prevents the consolidation of a sustainable circuit.

Spaces and uses on the route to the hill

The routes from the metro stations to the hill exhibit a differentiated spatial and functional slopes that run among a consolidated urban fabric, an urban fabric to be consolidated, and a natural edge ecosystem. These circuits show how the spaces and their uses directly influence the mobility experience and the potential to connect mass transport, micro-mobility, and the landscape.

The sequences of space and uses within the circuits take into account the neighborhoods' morphology and the district's topography. In the initial bus stops, there are consolidated neighborhoods, with metropolitan, zonal, and neighborhood trade. The roads are wide and have sidewalks, bike paths, and even gardens. The width of the streets is at the neighborhood or district scale. In neighborhoods on an intermediate slope, there is less consolidation, and neighborhood trade consists primarily of convenience stores. The roads are wide but

Theories	Findings	Relationship with the theoretical framework	Implications for conservation
Biophilia	Neighborhood participation for the management, use, and upkeep of the hill	Confirms the need for sensory and affective connection with nature	Community ownership strengthens landscape management and its symbolic value.
Sustainable urban mobility	Fragmented accessibility, multi-scale spaces and uses, informal local transport	Reflects the limitations of integrated land, transport, and green area planning	The lack of ecological connectivity reduces urban resilience and equitable access to the landscape.
TOD	Proximity to the Metropolitan Area and unconsolidated pedestrian access routes.	Contrasts the compact model of the TOD with the dispersed reality of the area	Requires strategies that integrate public transport and green corridors to conserve the area.

Table 1. Theoretical summary of findings and implications for landscape conservation. Source: Preparation by the authors.

irregular; they have sidewalks, streets, and even gardens. The width of the streets is on a neighborhood scale. In the neighborhoods on the upper slopes, there is limited consolidation; the only stores are convenience stores. The roads, in general, are narrow and irregular; they can be passageways, vehicle passageways, or stairs, without paved earth or cement sidewalks. The spaces have a neighborhood scale.

These results show an unplanned spatial and functional transition between mass transportation and a natural ecosystem, without pedestrian continuity or landscape criteria. However, in hillside neighborhoods, neighborhood appropriation is seen through the community facilities, residual open spaces, and spontaneous community uses, such as intense pedestrian circulation and neighborhood events, without infrastructure that consolidates this dynamic as part of the routes to the hill. This represents a strategic opportunity to link micro-mobility and pedestrian movements from neighborhoods to metropolitan nodes through TOD principles that integrate sustainable urban mobility and urban landscape (Table 1).

Local initiatives for the hill’s conservation

Hill conservation is primarily supported by local community-based initiatives managed by neighborhood organizations, environmental groups, and institutional stakeholders at the district scale. These emerge in response to the lack of specific public policies for managing hill ecosystems in Lima, which constitute an incipient, yet active, environmental governance system.

The local initiatives by the neighbors can be classified into cultural, educational, sports, recreational, community, and management initiatives. Among the most frequent actions to conserve the hill are community cleaning and reforestation days; guided ecological walks, trekking, hiking, environmental

education activities led by youth groups and local teachers; thematic parades, photo exhibitions, self-managed ecotourism projects, as well as neighborhood warnings and complaints against invasions, dumping sites, and uncontrolled burning. These practices have made the ecological and landscape value of the hill visible by fostering social appropriation of the area and community environmental awareness. These initiatives impact the use, protection, and upkeep of the hill’s access points. It is also worth noting that there are municipal programs and projects aimed at integrating the hills into the urban fabric through forestation, circular economy, and ecotourism circuits. However, so far, they have had limited impact on the hills and have not considered hillside neighborhoods in their strategies.

Nevertheless, over time, these initiatives have faced structural challenges: a lack of technical and financial resources, weak institutional articulation, limited continuity, and constant pressures from informal urbanization. Despite this, there are also strategic opportunities, such as increasing citizen awareness, valorizing the landscape as a common good, and linking these community actions to metropolitan strategies for sustainable mobility and ecological planning. In this context, the hill’s conservation becomes a process of social and local co-management, where local stakeholders play a key role amid institutional gaps, opening the possibility of integrating community governance and sustainable urban planning (Table 1).

VI. DISCUSSION

The case questions the relationship between sustainable urban mobility and landscape conservation in informal peripheral urban areas where planning is fragile and informal expansion is the dominant pattern. At the same time, the case forces a rethinking of the TOD model in informal contexts.

Namalwa et al. (2024) and Bressane et al. (2024) highlight the importance of improving institutional policies and frameworks that affect the conservation of green spaces in vulnerable urban areas, given the lack of coordination among institutions and the ineffective implementation of regulations. Meza Llinás (2021) and Iusry Abulatif et al. (2020) indicate that development using the TOD model in Latin American cities presents challenges such as the lack of homogeneity around transport nodes.

On the hill, the TOD model is working in an incipient way thanks to the combination of State and community management, as the participation of the district's residents is decisive in generating awareness and engagement, and in maintaining access to the hills. The case shows that community conservation and local mobility practices constitute non-formalized, but functional, sustainable urban mobility mechanisms that can be strategically integrated into public policies. The nearby metropolitan infrastructure, such as the Metropolitan bus system, is insufficient to generate sustainable urban mobility. Because of this, it is necessary to develop local mechanisms that enable a true connection to the hill, linking accessibility, uses, multi-scale spaces, and neighborhood participation.

The circuits to the hill underscore the need for multimodal transport, given the district's morphology and topography. This shows that it is necessary to rethink how the TOD model is inserted in these neighborhoods. Therefore, the case study allows reflection on the importance of using micromobility to link TOD nodes and urban landscape areas, especially in districts with neighborhoods of diverse urban scales, such as Independencia, which has spaces at both metropolitan and neighborhood scales. Several studies (Pomaquero-Yuquilema & Sánchez-Valdez, 2020; Iturraran Zapata et al., 2023) have indicated that micromobility, or neighborhood mobility, across different scales is a determinant of sustainable urban mobility. However, it is argued that the neighbors only create these means in a basic way, rather than the State, when the landscape areas are green spaces in the city that deserve greater protection. This could, at the same time, represent an opportunity to improve on-site micro-mobility conditions from the State when considering local initiatives.

The case study also raises questions about how urban uses can improve the circuit to the hills or to any landscape area. In the case study, although these uses are not strictly designed for the hill's benefit, but rather for the district's needs, they help generate more attractive routes to the hills, especially at the neighborhood and inter-neighborhood scales (Figures 4 and 5). This represents an opportunity to promote more urban uses linked to the hill to strengthen the circuits.

VII. CONCLUSIONS

Analysis of the hill shows that the relationship between sustainable urban mobility and landscape conservation in informal urban contexts presents challenges and opportunities that must be addressed together. Firstly, regarding accessibility at the metropolitan and local scales, there is a disconnect between the mass transport infrastructure (metropolitan stations), provided by the State, and the local mobility systems proposed by the neighbors. Although the hill is located close to TOD nodes, the lack of green corridors between the hill and these nodes reveals the absence of multimodal planning that integrates transport and landscape.

Secondly, the types of spaces and uses along the route evidence a slope that transitions from consolidated areas, with intense urban activities on a metropolitan scale, but lacking sustainable urban mobility infrastructure designed to protect the hill, towards transitional spaces with uses on an inter-neighborhood and neighborhood scale, and, finally, towards an ecological edge with improvised paths. This spatial sequence has not been planned, which presents a challenge, but also an opportunity, since although the morphology of the hillside neighborhoods limits accessibility, it also opens the possibility of structuring landscape corridors with multi-scale spaces that combine local mobility and ecological conservation under TOD principles.

Thirdly, local conservation initiatives are a relevant form of social capital that enables sustainable practices in environmental education, responsible ecotourism, and community monitoring. These initiatives face structural challenges (financing, inter-institutional coordination, urban pressures), but they also create opportunities to align with Metropolitan policies on sustainable mobility and ecological management. Public policies for ecosystem conservation should include neighborhood participation, since it is not institutionalized, and neighbors work in a self-managed manner. The residents of the hillside neighborhoods are an important group in preserving access to the hill, as their surveillance and cultural activities foster security and revitalization.

The article contributes to the debate on sustainable urban mobility and landscape conservation in Latin American metropolitan contexts by showing that the TOD model can be adapted to informal urban contexts if the importance of urban ecosystems and the active role of local communities are recognized. This integration of accessibility, landscape, and community management not only improves connectivity across multiscale areas but also redefines

urban mobility as a local sustainability strategy, strengthening the bonds between the city and nature.

VIII. CONTRIBUTION OF AUTHORS CRediT:

Conceptualization, D.L.Q.T., O.F.C.V.; Data curation, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.; Formal analysis, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.; Acquisition of financing, D.L.Q.T., O.F.C.V., A.R.C.; Research, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.; Methodology, D.L.Q.T.; Project Management, D.L.Q.T.; Resources, D.L.Q.T., O.F.C.V., A.R.C.; Software, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.; Supervision, D.L.Q.T.; Validation, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.; Visualization, D.L.Q.T., I.V.D.C.; Writing – original draft, D.L.Q.T.; Writing – revision and editing, D.L.Q.T., O.F.C.V., I.V.D.C., A.R.C.

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