

LANDSLIDE SCARPS, AS EXEMPLIFIED BY RECREATIONAL URBAN AREAS IN EUROPE AND SOUTH AMERICAN COASTAL CITIES

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Abstract

Landslide scarps are steep landforms formed at the top of a landslide, where a mass of earth or rock has separated from a stable subsurface. Their presence in cities poses a significant engineering challenge and a hazard to residents, given the availability of these dangerous areas for recreation and tourism. In Poland, in the Gdańsk and Sztutowo areas, the sand slopes of beach recreational areas are protected by retaining walls and an erosion-control plant (*Rosa rugosa*). Roses also serve a decorative function and are part of the protected landscape of Pomerania. In Lima, South America, slate slopes are protected by metal or linen nets that shield pedestrians, cyclists, and public transport. This is also a suitable habitat for groundcover plants, which can cover the drab landscape, but require irrigation, a pressing need in a country with limited water resources and the development of tourism in the Milaflores district due to picturesque ocean landscapes and the coastline offering beach leisure activities. This paper demonstrates climatic, cultural, and recreational differences and explores how landscape architecture and ecological engineering can address slope stabilisation in cities while simultaneously ensuring human well-being, the development of coastal leisure facilities, and the quality of recreation, as well as strengthening the role of tourism in protected landscapes in urban areas.

Key words: nature protection, recreation, cover plants, Lima, Gdańsk

Introduction

Landscape architecture and ecological engineering techniques in European and South American coastal cities differ significantly based on geological substrate, climatic challenges, and resource availability (Alexander, 1989; Begemann, 1999; Pike et al., 2003; Schuster & Highland, 2007; Latrubesse, 2009; Morino et al., 2022). This applies especially to places with different substrates and environmental conditions. Coastal towns often serve as places for recreation and tourism. However, they are not always adapted to the needs of visitors, e.g., unsecured or improperly sloped cliffs make it impossible for tourists to move around and engage in active recreation on beaches and squares, and consequently, there is a risk of injuries and, as a result, an economic decline in the region. This article brings the topic of managing land development in places with different substrates – stable and unstable soil- closer. Thanks to our research at the intersection of landscape architecture and ecological engineering, as well as recreation and tourism, we can obtain various examples and methods of stabilising slopes, which may provide a response to climatic events and El Niño, which destroy the landscape and economic resources of the area that require ongoing maintenance, post-warranty repairs, or revitalisation.

Material and methods

The study utilised materials collected during field research conducted by the team in the capital, Lima, and the Milaflores European district (Peru), and in the cities of Gdańsk and Sztutowo (Poland) in 2024-2025. The research employed a mixed-methods design (Alexander, 1989; Begemann, 1999; Niezabitowska, 2014; Morino et al., 2022), grounded in a literature review of slope stabilisation and recreational needs in coastal leisure areas. The research questions are as follows:

- 1) What are the differences in slope stabilisation between Gdańsk and Lima?
- 2) How does landscape architecture combine safety with tourism needs?
- 3) What is the role of ground cover vegetation in protecting cities from landslides?

Results

The coastal landscape of Pomerania (Poland) consists of sands that form dunes through changes in the landscape, weather, and storms. Recreational beaches look different each time. The permeable soil is a good place for shrubs such as roses (*Rosa rugosa*) and Scots pine (*Pinus sylvestris*), which naturally occur in this landscape (Figure 1).

The Miraflores district in Lima (Peru) is a European-style capital attracting many tourists. Maintaining these areas requires significant financial outlays, including irrigation and fertilisation, which are crucial in this part of South America. The area is abundant, with a large waterfront featuring playgrounds, soccer fields, and natural-surface pedestrian and cycle pathways. Active leisure zones are surrounded by grassy areas, shrubs, and ornamental trees typical of tourist resorts, which withstand the subtropical climate and serve decorative functions, influencing the local microclimate. From the Pacific Ocean side, a long beach stretches, with spaces for beach games, separated from the built-up area by a steep cliff mechanically shaped for the development of an expressway. The physical properties also require securing the steep and rugged slopes of the parent rock shale (Figure 2).

In European cities like Gdańsk and Sztutowo, selected for case research, stabilisation efforts are primarily aimed at sand slopes in beach recreational areas. The key issue is engineering methods (Begeman, 1999) that protect the slopes through a combination of retaining walls and erosion-control plants. However, an important issue in designing and protecting the site's landscape is vegetation selection, with the primary plant being the rugosa rose (*Rosa rugosa*). The roses serve a dual purpose: they provide structural stability while also serving as a decorative element considered an integral part of the protected landscape of Pomerania. These areas, although separated by a fence, are unfortunately common places for informal toilets because there are not enough toilets or they are not paid for. Recreation therefore takes place directly on the beach, close to the sea, where one can set up recreational equipment, as well as by enjoying the landscape on the pier, which is a common part of walks, especially on weekends (Figure 1).



Fig. 1: Development of the waterfront in Gdańsk and Sztutowo (Pomerania, Poland) – natural coastal vegetation protecting the slopes: pines (*Pinus sylvestris*), sedges (*Carex sp.*), dogwoods (*Cornus mas*), and rugosa rose (*Rosa rugosa*), a natural beach shaped by dunes and sea waves for active and passive recreation (used mostly in the summertime), and a wooden pier popular with tourists (all seasons). Photos by. A. Długoński, 2024.

In contrast, cities like Lima face slate slopes, requiring different technical interventions to manage a "drab landscape" and ensure public safety. Engineering methods based on stabilization (Morino et al.,

2022), which is achieved through the installation of metal or linen nets. These structures are vital for protecting pedestrians, cyclists, and public transport from potential rockfalls or landslides. While groundcover plants are used on these nets to improve aesthetics, they require artificial irrigation. This creates a significant engineering and environmental challenge because Peru has limited water resources. Looking at the Urban Context design methods in South America, they are often driven by the need to support rapidly developing tourism in coastal districts like Miraflores, where picturesque ocean landscapes have to be balanced against high geological risk (Figure 2).



Fig. 2: Development of the slope (multifunctional sports and walking park) in the Milaflores district (Lima, Peru). Photo by DJI Mini 4K Drone, Andrzej Długoński, 2025.

The Peruvian example is therefore a good result achieved by the designers on a relatively small area and with limited development possibilities. Recreation is possible, and the varied forms of recreation

offer sports in the evening due to lighting availability and residents' and tourists' free time. These elements make the slope area decorative and accessible to users both in winter and summer.

It is worth noting that South American techniques must account for extreme climatic events, such as the El Niño effect, which can trigger intense rainfall, floods, and landslides, placing immense pressure on coastal infrastructure. In many South American cities, rapid urbanisation has pushed informal settlements onto steep, hazardous slopes, making complex drainage systems and landslide mitigation a matter of critical life safety rather than just landscape aesthetics.

Discussion

Differences in slope stabilisation between Gdańsk – Sztutowo and Lima result from different geological and climatic conditions and available resources. In Pomerania, Poland, the sandy slopes of recreational areas near beaches are protected with retaining walls and erosion-control vegetation. The main species used to reinforce the slopes is *Rosa rugosa*. This plant, besides its stabilising function, serves a decorative purpose and is considered part of the protected landscape of Pomerania. In Lima, South America, slate slopes are secured using metal or linen nets. These solutions primarily aim to protect pedestrians, cyclists, and public transport. Ground cover plants are planted on the nets to improve the aesthetics of the 'grey landscape'. However, unlike in Pomerania, vegetation in Lima requires artificial irrigation, which poses a significant challenge given the country's limited water resources.

The review of sources and our observations, however, do not mention specific plant species used in the capital of Peru. They only point to a significant challenge related to their maintenance: due to Peru's dry climate and limited water resources, these plants require artificial irrigation. In comparison, in the case of Gdańsk, sources precisely indicate the use of rugosa rose (*Rosa rugosa*). Linen nets support vegetation on slopes primarily by creating a suitable habitat for ground cover plants. It is, however, worth remembering that in dry conditions (as in Lima), the net alone is not enough for vegetation to survive – artificial irrigation is also required, which constitutes a major challenge due to limited water resources in Peru.

Conclusions

In summary, while Polish examples focus on the natural integration of vegetation into the protected landscape, Peruvian examples rely on technical solutions (nets) and face difficulties maintaining greenery in a dry climate. However, both studied cases share the aim of ensuring safety in areas of intense tourist and recreational traffic.

Our results indicate that plants with anti-erosion properties effectively protect unstable coastal soils. The rugosa rose (*Rosa rugosa*) is considered effective in coastal protection, primarily responsible for stabilising sandy slopes. It is used to protect sandy embankments in recreational areas near beaches (e.g., in Gdańsk and Sztutowo), often in conjunction with technical solutions, such as retaining walls that separate the recreational area from areas protected for natural plants. Thanks to natural reinforcements, the recreational landscape is not destroyed and remains decorative. Anti-erosion plants are therefore a good solution for sandy shores to preserve recreation and the protected natural landscape of Pomerania.

In Lima, rocky soils make it difficult to plant plants that improve the region's landscape aesthetics and tourism in Peru. On metal or linen nets securing the slopes in Lima, ground-cover plants are planted to enhance aesthetics and cover the grey landscape. Their primary function is to ensure safety and protect users of urban spaces, including pedestrians, cyclists, and public transport users, from hazards resulting from the proximity of shale slopes. An important role is to cover the "grey landscape" and improve the aesthetic qualities of the coastline. On steep slopes and rocky terrain, ropes and nets with climbing vegetation work well, which allows for safe recreation, and this is a commonly used method in mountainous areas.

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Souhrn

Tento výzkum ukazuje, jak se krajinářská architektura a ekologické inženýrství využívají ke stabilizaci pobřežních svahů náchylných k sesuvům půdy v různých městských prostředích za účelem aktivní i pasivní rekreace a cestovního ruchu. Porovnáním případových studií z Gdaňsku a Sztutowa (Polsko) a Limy (Peru) poukazujeme na to, jak odlišné geologické a klimatické podmínky určují různé stabilizační strategie. V Polsku jsou písčité násypy zpevňovány kombinací opěrných zdí a rostlin bránících erozi, jako je růže rugosa (*Rosa rugosa*). Naopak břidlicové útesy v Limě vyžadují technické zásahy, jako jsou kovové nebo lněné sítě, které chrání dojíždějící a turisty před padajícími kameny. Zatímco obě oblasti usilují o posílení cestovního ruchu a veřejné bezpečnosti, případ Peru poukazuje na další výzvu, kterou představuje udržení zeleně uprostřed závažného nedostatku vody a podpora udržitelné rekreace a místní ekonomiky.

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