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## Full Length Article

## Towards a landscape-based approach for planning and design in complex urban geomorphologies: A case study of Valparaíso, Chile

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## ABSTRACT

In the context of Chilean Metropolises such as Santiago, Valparaíso, and Concepción, ecological and social fragmentation of cities lead to significant environmental disturbances, including alterations to the urban climate, loss of biodiversity, and the gradual suppression of ecological corridors and native habitats, ultimately heightening current and future risks, and degrading the quality of life for urban residents stemming from excessive urbanisation, ineffective planning, maladaptive design, and environmental management in critical natural areas. Although an abundance of general frameworks and principles already exist, they necessitate a more contextual and integral approach that considers the natural dynamics of the landscape (landscape logic) as a base for social and economic development. This research presented a landscape approach taking the city of Valparaíso, Chile, as a case study. A methodological framework utilising mixed methods, was developed to analyse and diagnose potentialities of the landscape for developing practical knowledge for planning and design, conscious of the community demands and capacities, its ecological system and its complex geomorphology, and the future applications and assessment in biodiversity terms and social impact. A design-related research opens the opportunity as a methodology that will make it possible to incorporate different types of expertise and work on various scales. This research provides a means for developing spatial guidelines and design principles to strengthen Valparaíso's green/blue infrastructure at multiple scales. It will ensure water security, biodiversity conservation, safer and more inclusive spaces, and better integration of informal settlements while enhancing ecosystem services for the community. Additionally, by incorporating the natural dynamics of the landscape, this approach provides ways to reduce risk, promote adaptation, and build resilience.

## 1. Introduction

The accelerated urbanisation process suffered by cities is primarily the product of the authorities' lack of control over the space within their cities. Meanwhile, 55% of the world's population lives in urban areas; this figure is projected to reach 68% by the year 2050. Latin America is one of the most urbanised regions, with 81% of its population living in urban areas (UN, 2018). These phenomena also need to consider other physical and social conditions as the geomorphological condition product of the Andes Mountain range, the high rates of inequality and poverty in Latin American cities, as well as the consequences of ineffective land-use planning that privileges some interests over others, flexibilisation on land uses with a clear priority on intensification and expansion under an economic perspective only, following a neoliberal model firmly rooted in them (Schuster-Olbrich et al., 2024).

These policies have exacerbated environmental degradation by commodifying land and prioritising market-driven expansion over socio-ecological well-being, driven by ineffective planning that replaces or alters natural features with residential, industrial, and commercial developments, undermining ecosystem services and biodiversity and leading to fragmentation of urban and natural landscapes, as well as constant environmental degradation and increased socio-ecological vulnerability (Henriquez and Pavez, 2013; Schuster-Olbrich et al., 2024). Considering this summary of complex interrelated conditions, the reduction of the natural landscape and the conversion of land to urban uses to activate the economy of their countries are causing and increasing problems. These include biodiversity loss, degradation and fragmentation of ecological corridors and native habitats, which in turn increase environmental hazards, risks to cities, and diminished quality of life for both inhabitants and ecosystems.

Meanwhile, Chilean metropolitan cities such as Santiago, Concepción and Valparaíso are part of a broader ecosystem, playing a

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crucial role in the planning and design of their urban areas as they adapt to climate change and its associated impacts, ecological and social fragmentation of their natural areas, along with the various factors of diverse regional hazards (droughts, floods, landslides, forest fires), intensifying due to urbanisation and territorial planning processes that hinder effective environmental management. This situation is evidenced by the continued segregation and degradation of natural elements within the main Latin American urban areas in a scenario of increased risk and increased socio-environmental conflicts (Santibañez-Frey, 2019). In this sense, there is no doubt that adaptation to climate change and urban expansion is an urgent reality to move toward resilient and adaptive landscapes (Zucchetti et al., 2020).

The problems associated with the city occur at the interface between the natural environment and the urban area. In context with complex geomorphology, as mentioned above, the expansion of urban fabric is confronted with the hill where the development and the coexistence between the urban and natural areas do not exist, consolidating the idea of an urban remnant that today weighs on natural corridors (ravines), and that together with disregarding the present cultural and ecological value, disregards the importance of the ravines both in the construction of the city's image and in the articulation of public space (Fig. 1). Most of the natural systems in the ravines where the expansion has slowly degraded have been outside the urban imaginary for a long time despite being essential to the natural conditions of the territory. The development of infrastructure and informal settlements in these ravines reduces green spaces and contaminates soils and waterways, negatively impacting ecological integrity.

However, the ravines are also a key place that presents opportunities for integrating these spaces in the city, restoring the value of its origins. Thanks to its configuration, it is the place that would allow the integration of the green spaces and be a fundamental part of the system of open spaces of the city, reconvert one of the most vulnerable and degraded areas in the key and structuring element of the urban green, providing multiple ecosystemic benefits. The re-naturalisation and revalorisation of the ravine and its aligned socio-ecological system must be accompanied by planning that recognises its potential as a refuge for the city's biodiversity, the commune, and the region and shift the paradigms from the prioritisation of the economy based on an extractive model to looking after social needs and ecological processes

which have a direct impact on the consequent high level of vulnerability and the effects of climatic pressures on urbanised areas.

Various frameworks strategies and principles, such as water-sensitive approaches (Wong et al., 2020), watershed management (Steiguer, 2003), offer potential directions for this research. These concepts emphasize the importance of understanding hydrological processes, their interactions, and the cumulative impact of urban expansion on water systems. While each framework has distinct perspectives, they share a common goal: using water management to enhance urban resilience, sustainability, efficiency, and overall quality of life (Russo et al., 2008).

Meanwhile, with increasing environmental degradation at both national (Marquet et al., 2021) and global levels, nature-based solutions (NbS) as part of ecosystem-based adaptation strategies have also emerged as a key strategy for tackling urban challenges and strengthening the resilience of both societies and ecosystems (Pauleit et al., 2017). NbS is characterised by a problem-solving approach (Hansen et al., 2014) in which cases such as The International Union for Conservation of Nature (IUCN) Global Standard for Nature-based Solutions, through its framework with eight criteria and twenty-eight associated indicators (IUCN, 2020), are recognised as a viable path towards more sustainable urban and rural development (Albert et al., 2021) through cross-sectoral integration at multiple scales.

In response to the growing inertia of urban planning and the undisputed dominance of civil engineering at the end of the 20th century, landscape infrastructure emerges to redefine the conventional role of infrastructure in the future of urbanised regions. Bélanger (2009) established the concept of landscape infrastructure that foregrounds the dynamics of living, biophysical systems historically marginalised by the gap between the economy and ecology of large cities, repositioning the landscape as a complex system, instrumental to the essential services, resources and processes that underpin contemporary urban economies in which green infrastructure has been seen as key to meeting the challenge of sustainable urban transition (EU, 2019).

However, despite their potentialities, these frameworks and strategies face constraints in cities like Valparaíso, where urban planning remains influenced by 20th-century paradigms and is shaped by complex metropolitan, cultural, socio-economic, political, and administrative structures (Prieto and Rodríguez, 2015). To overcome these limitations, a broader conceptualization of landscape—not merely as



Fig. 1. Contrast in the interface between the natural environment and the urban area.  
Source: By the author.

aesthetic or natural spaces but as a comprehensive and integrative framework—could serve as a unifying approach for incorporating these strategies effectively. In this sense, a landscape-based approach opens the field as an opportunity to be a strategic line for adaptive and resilient landscapes at the communal, regional, and national levels. A landscape-based approach for Valparaíso requires careful consideration of the specific contextual and spatial characteristics shaped by the Andes and Coastal range. The unique combination of ecosystems, geomorphological and hydrological conditions, and the presence of informal settlements presents complex challenges that call for a more tailored design and planning strategy, with adapted design principles, methods of understanding, and context-sensitive indicators.

Valparaíso, the main port city in Chile, due to its geomorphological conditions, distinct natural elements as been part of one of the world's biodiversity hotspots, sensitive ground water system and social dynamic from the informal settlements, is presented as a paradigmatic example of the multiple urban situations that can occur in ravines, transcending its singularity and providing valuable lessons for urban planning in other cities in the region by establishing and strengthening a network of green and blue infrastructure connecting open spaces, can transform ravines into platforms for public recreation, enhance connectivity within the urban fabric, and improve the provision of ecosystem services while linking urban areas to their surrounding natural landscapes.

Applying a landscape approach without accounting for distinct natural elements—such as the Chilean matorral ecosystem<sup>1</sup>—alongside complex geomorphological conditions, including steep coastal valleys and sensitive groundwater systems, and socio-ecological dynamics, such as informal hillside settlements, intensifies the contradiction between the ecological support provided by nature and the demands of the built environment. To ensure that the landscape approach leads to more inclusive, resilient, and ecologically grounded outcomes, further research is needed. This research should focus on developing context-specific ways of understanding, refining indicators that reflect local socio-ecological realities, and formulating design principles and strategies attuned to Valparaíso's layered landscape dynamics.

Efforts in urban ecological integration are being made, and more and more cities are proposing to develop an interconnected ecological network at the regional level to have a base matrix that guarantees the conservation and delivery of ecosystem services to the cities. The objective is the coupling of anthropic systems to natural systems. Thus, the Metropolitan Strategic Land Use Plan 2018–2030 (PEMOT) for the Aburrá Valley and Medellín.<sup>2</sup> The Metropolitan Urban Development Plan of Lima and Callao 2040 (PLANMET2040)<sup>3</sup> or the Eco Local Plan 2030 - GEF Mountain in Chile (2021),<sup>4</sup> which proposes a matrix of Mountain biological corridors for Santiago and its geographic region. In

all, it is common for them to want to transition from weak to strong sustainability, focusing on the landscape's adaptability and resilience.

The current paper and related research aim to lay the foundations in terms of objectives and methodology to understand the reality in the context of the Global South in many Latin American cities to address these challenges and shift toward a landscape-based approach that considers the ecological, social/cultural, and geomorphological system as a value within the urban development. This approach emphasises the understanding and incorporation of the specific contextual and spatial characteristics from the context into practical knowledge to revitalise the natural spaces and promote adaptability and resilience in urban and natural environments. In this context, the historical absence of institutions, instruments, and practical knowledge for designing and planning in Latin American cities has resulted in specific forms of landscape degradation and unsafe conditions, amplifying risks to the territory. In accordance with the above, four knowledge gaps have been detected that are necessary to work with:

- (1) The understanding and integration of landscape as an integral approach in urban environments in terms of planning and management, and the process of designing a potential solution in the territory. Considering landscape only in terms of its appearance (aesthetic approach) tends to generate and promote conservation policies that do not incorporate functionality, processes, links between elements and even less with the communities that influence its transformation or vice versa (Nello, 2004).
- (2) The absence of an integrated vision in the process of planning and design has allowed the development of informal settlements, the degradation of critical natural areas, and the progressive atomisation of ecosystems, particularly across cities where the geomorphology is present. These processes have not only disrupted ecological continuity but also exacerbated socio-ecological vulnerabilities and increased risk within the urban fabric.
- (3) The recognition and integration of the geomorphology as an inherent condition of a territory, as well as the social system (urbanisation expansion and informal settlements) and the ecological variables (natural system and water system) present in the territory of Valparaíso and the inhabitants who live in these places, are not yet planned or considered at the possible transformative design process of the territory.
- (4) The variability of the responsible planning institutions perspectives and operations hampers the integration of risks as a multi-scale problem, coupled with the sectoriality of various existing databases and digital platforms, which complicate data integration from macro-scale (GIS) to micro-scale analysis and vice versa.

To summarise, there is a lack of a method to understand and recognise the complex geomorphological conditions and socio-ecological systems, along with a framework for natural landscape planning and design that can translate both new and existing knowledge into valuable design insights for degraded, segregated, and vulnerable areas. Using Valparaíso as a case study, its particularities from the context and its landscape illustrate the complex urban challenges that result from development in such a geomorphological condition. The city's distinctive topography, natural system and socio situation not only emphasises the difficulties associated with these environments but also uncovers opportunities for broader application throughout the Chilean landscape and other Latin American cities facing similar challenges in which a landscape-based approach recognises the complexity and interdependence of ecosystems, water cycles and human settlements and incorporates them, enabling the adaptive design of resilient environments that can withstand the urban growth processes and the effects of climate change more effectively. In addition, landscape strategies enable the spatial coordination of planning and design principles and ensure that solutions are not only ecologically but also socially integrated and tailored to the needs of different communities, providing a conceptual and operational framework to bridge these gaps.

<sup>1</sup> The Chilean matorral is a Mediterranean-type ecosystem found in central Chile, characterised by sclerophyllous (hard-leaved) shrubs, endemic plant species, and high biodiversity. It is adapted to dry summers and wet winters, and plays a vital role in regional ecological stability and climate regulation.

<sup>2</sup> Área Metropolitana del Valle de Aburrá. (n.d.). Plan estratégico metropolitano de ordenamiento territorial. Metropol.gov.co. <https://www.metropol.gov.co/planeacion/Paginas/plan-estrategico-metropolitano-de-ordenamiento-territorial.aspx>

<sup>3</sup> Instituto Metropolitano de Planificación. (n.d.). Plan de Desarrollo Metropolitano - PLANMET 2040. <https://portal.imp.gob.pe/planificacion/plan-met-2040/>.

<sup>4</sup> MMA - ONU Medio Ambiente, 2020. Planificación Ecológica a escala local 1:25.000, para todos los municipios pertenecientes al área del proyecto GEF Montaña. Estudio encargado a: Dr. Alexis Vásquez, Dr. Emanuel Giannotti, Dr. Álvaro G. Gutiérrez, Dr. Ezio Costa, Elizabeth Galdámez, Ms. Ignacio Núñez, Camila Muñoz, Aaron Hebel, Macarena Martinic y Héctor Yáñez. Facultad de Arquitectura y Urbanismo, Universidad de Chile. Financiado en el marco del proyecto GEFSEC ID 5135 Ministerio del Medio Ambiente - ONU Medio Ambiente. Santiago, Chile. p. 187.



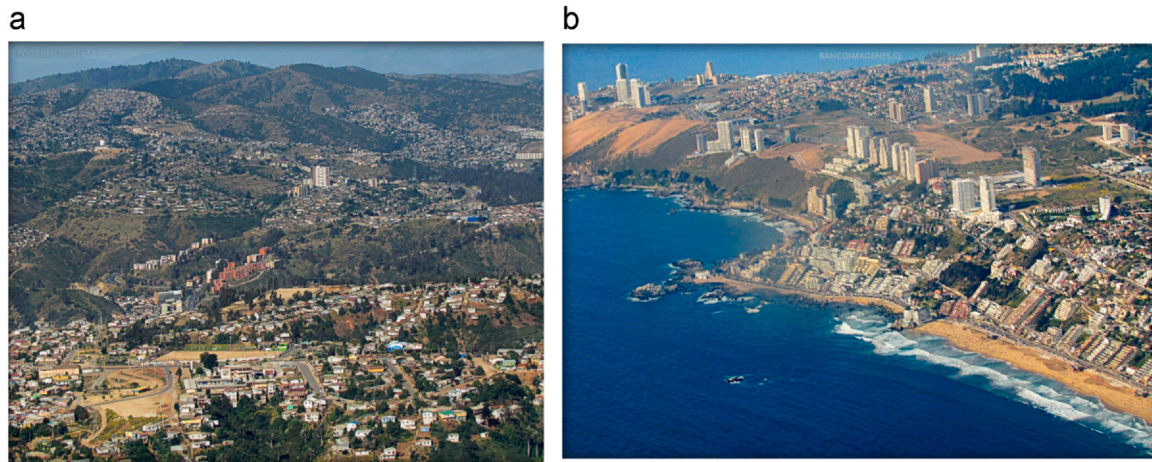


Fig. 2. Examples of urban sprawling in Valparaíso as in the region's interior (a) or at the coast (b).  
Source: [Megaconstruccionen.net.net](https://megaconstruccionen.net.net) (n.d.).

## 2. Territorial effects of urbanisation process in Chile

Currently, the urbanisation by extension have generated profound changes both in society and in natural space, coupled with processes of socio-ecological degradation aggravated by the rapid expansion of cities, manifesting a differentiated behaviour that can be appreciated at global, regional, and local levels in terms of the transfer and concentration of the negative externalities of the urbanisation process and the construction of risk, towards more vulnerable territories (Martínez, 2014). In this sense, the degree of deterioration of urban and natural ecosystems is related to multiple factors, for example, the lack of land regulation, the overexploitation and privatisation of natural resources and public use goods, the inequity present in the access to ecosystemic services, the asymmetry in the decision making of the actors involved in the production of space, among others (Romero, 2007) (Fig. 2). In this sense, the problematisation of this study is separated into three parts to understand the operability of the urbanisation process in the Chilean context (Section 2.1), the issues associated with the socio-environmental decay of Valparaíso (Section 2.2) and the increase in the degradation and the risk of the territory and the potential areas to project adaptive and resilient landscapes (Section 2.3).

### 2.1. Chilean urban and planning processes

In Chile, alongside the clear impacts of climate change, the growth of cities, particularly within metropolitan areas, has occurred under precarious spatial planning, where immediate economic gains take precedence, and the territories are altered without regard for the continuity of natural spaces or the landscape dynamics and its sub-component particularities at each place. These trends have led to significant degradation in the natural environment, contributing not only to escalating environmental issues but also to various risk factors and degrees of degradation that affect the loss of ecosystem services provided by nature to local communities.

Despite displaying multiple vulnerabilities and segregation levels, they are only recognized and tackled in the aftermath of disaster events (triggered by natural or human-induced hazards, such as floods, wildfires, or landslides). The governmental responses to these challenges have typically been focused on developing infrastructure projects that prioritize immediate solutions for isolated issues, neglecting the interaction of numerous factors that affect the territory and often exacerbating new adverse situations in the long term. According to this, a physical territory is in permanent tension and the undervaluation of its urbanisation processes, negatively affecting cities' environmental and social conditions. This scenario constitutes

a challenge when articulating variables for sustainable development and resilient landscapes.

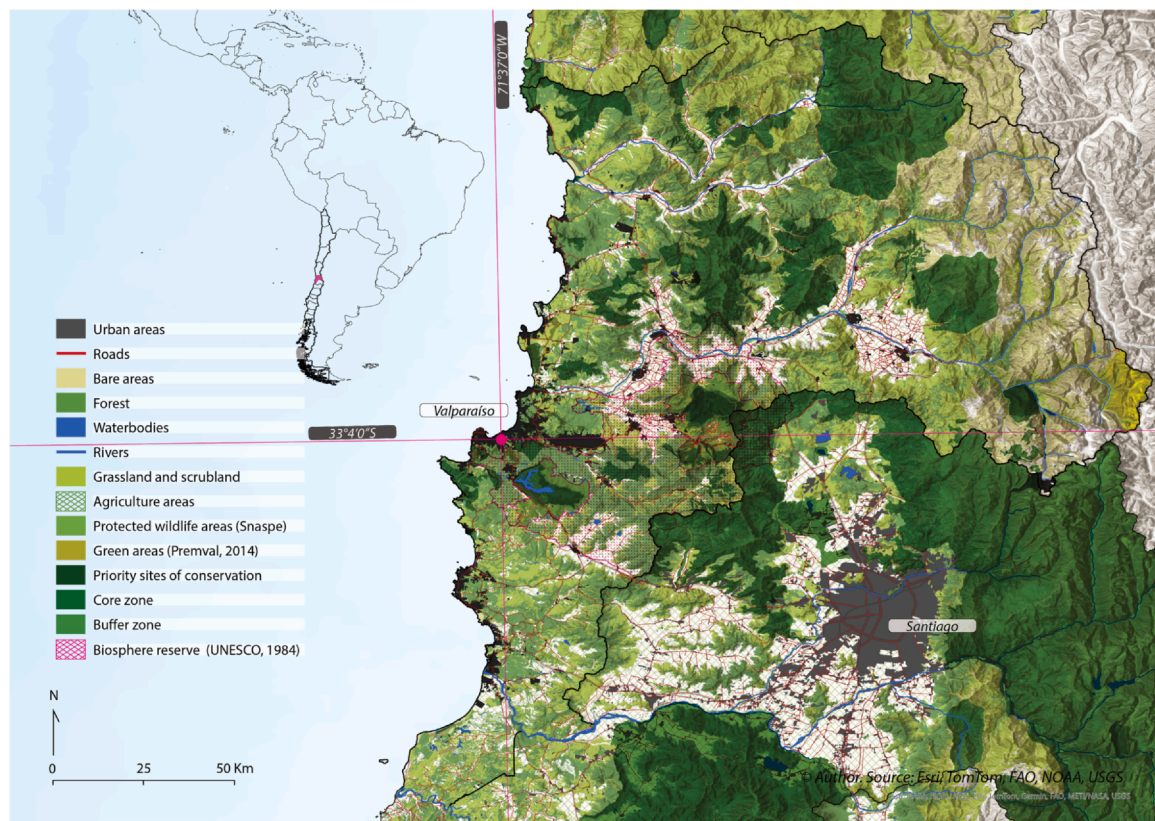
Another evidence at the local level, as in the Chilean case, is reflected in the scarce capacity of urban planning instruments until the mid-1990s, concerning the consideration of the natural system in the planning of Chilean cities. According to Larraín (1992), geophysical and seismic risks were practically the only variables considered, evidencing the emerging need to transform urban planning into an interdisciplinary and transdisciplinary activity. The reasons for this exclusion are to be found in:

- (1) The State's role has favored extensive growth through permissive norms and concrete action, such as the direct or indirect construction of basic housing in unconsolidated urban areas with a clear economic and immediate focus. The only criterion that has prevailed is the low value of land and the need to reduce the housing deficit, ignoring others such as social costs or socio-environmental externalities in the medium and long term.
- (2) The historical subordination of Chilean urban planning to real estate and construction interests is also the responsibility of the State.
- (3) The economic and political importance of the construction sector has ensured a practically unchallengeable influence on urban planning. This situation has resulted in extraordinarily permissive legislation functional to the economic interests of the groups involved, allowing them to minimise or omit any environmental considerations that affect those interests.

In the context of the urban growth scenario experienced in the country and consolidated towards the end of the 1990s [with an average annual Gross National Product (GNP) growth of 6% in the period 1986–2001 (Beyer, Vergara, 2002)], the State developed a substantial improvement in the institutional framework (Political Constitution of Chile, Art. 19, N. 8)<sup>5</sup> and the implementation of environmental assessment instruments (Law 19.300 and Law 20.417),<sup>6</sup> which allows the introduction of this dimension in territorial planning and acknowledges them into the execution of development projects.

<sup>5</sup> Constitution of Chile, Art. 19, N. 8: "The right to live in an environment free of pollution. The State must ensure that this right is not affected and protect the preservation of nature. The law may establish specific restrictions on the exercise of certain rights or freedoms to protect the environment."

<sup>6</sup> Law 19.300: Approves law on a general basis of the environment. Law 20.417: Creates the Ministry, the Environmental Assessment Service and the Superintendence of the environment.



**Fig. 3.** Regional scale, Valparaíso. Geoprocessing and overlaying different shapefile data using ArcGIS Pro (Esri). Data collected from USGS (<https://earthexplorer.usgs.gov/>) and IDE Chile (<https://www.ide.cl/>). Source: By the author.

Despite these considerations, there is evidence of a limited capacity of the State to establish an adequate balance in our cities, which is reflected in the broad spectrum of urban inequalities and environmental conflicts initially present in metropolitan areas, as in the case of Valparaíso. This opens the opportunity for new approaches to be implemented in the Chilean context.

## 2.2. Valparaíso: An unplanned city

Valparaíso is a port city in central Chile, in the Valparaíso Province in the Region of Valparaíso. The consolidation of the Metropolitan Area of Valparaíso is based on a model of growth by the addition of urban patches, resulting in the functional and interdependent conurbation of the cities of Valparaíso, Viña del Mar, Concón, Quilpué, Villa Alemana and Placilla-Curauma satellite towns (Figs. 3 and 4).

The extensive urban development pattern that has taken place with a growth rate of over 400 ha per year has had a series of effects on the environmental structure of the different cities that make up the conurbation, consolidating the Metropolitan area of Valparaíso (Romero et al., 2009). The different road structures, such as the high-speed transport networks (Route 68 and interurban roads, Troncal Sur and the Las Palmas Highway) that connect and structure the geographic dispersion and explosive growth of the urban sprawl, which in the period between 1975 and 2004 has almost tripled the area (Muga et al., 2007).

The city historical lack of spatial planning and integrated management of its natural resources, mainly focuses on an urban vision that prioritises the problems related to infrastructure, mobility, transport, and waste treatment (Santibañez-Frey, 2019), brought serious environmental issues such as the loss of important biodiversity, positioning it as a significant area of ecosystem degradation. This impact is felt most critically by the most vulnerable inhabitants, who face unequal access to essential infrastructure and environmental resources

and services from the natural areas. As a result, they often find themselves in a constant state of marginalisation (Romero, 2007), lacking security against various risks that have increased over the years as a product of the effects of climate change.

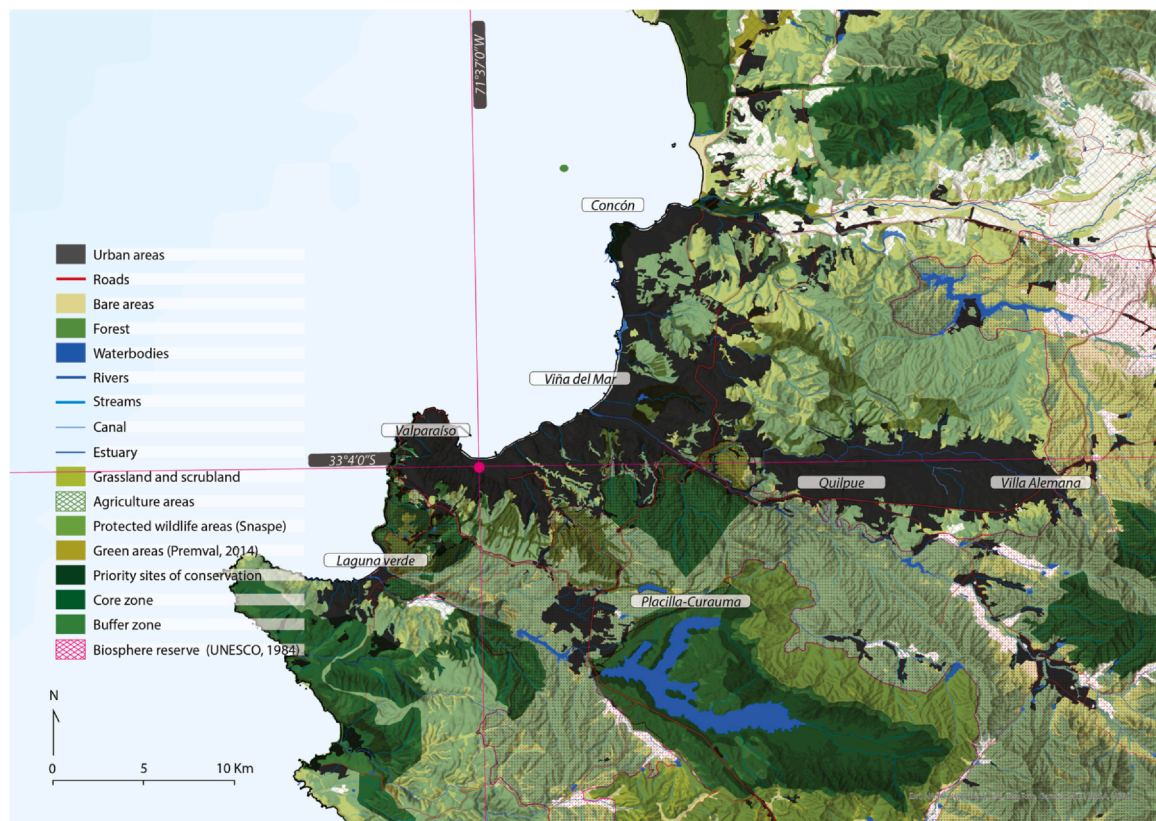
In this sense, the city of Valparaíso, within its large bay and amphitheater plateau, is seen as a key element in integrating a system of green areas that came from its geomorphological condition (ravines), which, through the consideration of strengthened the socio-ecological variables and incorporating a network of green/blue infrastructure, can project an adaptive and resilient natural and urban landscape for Valparaíso projecting it as a platform for public recreational use, it encourages interaction and contact between neighborhoods and populations, linking them with the natural areas (Fig. 5).

Under these current conditions in the described territory, the recognition of constructive values such as the geomorphology and the socio-ecological dynamic and interrelated variables are recognized as vital to favor correct planning, management and design of the territory and also to facilitate the integration of threatened landscapes safeguarding their biodiversity, looking for a way to integrate the urban and the natural under conditions that allow the development of both; ensuring that nature is not only preserved but also prioritized for the development of the social and economic system (Nijhuis, 2022).

## 2.3. Socio-ecological degradation, segregation, and risks as spatial opportunity: rescuing natural remnants in the city

With the arrival of modernization and as a result of expansive urban growth, the country's principal port extended toward its operational infrastructure to the interior of the basin, giving life to different settlements such as Viña del Mar, Placilla, Quilpué and Villa Alemana and installing different associated infrastructures as a predominant means of transport for the connection between cities [train line Valparaíso



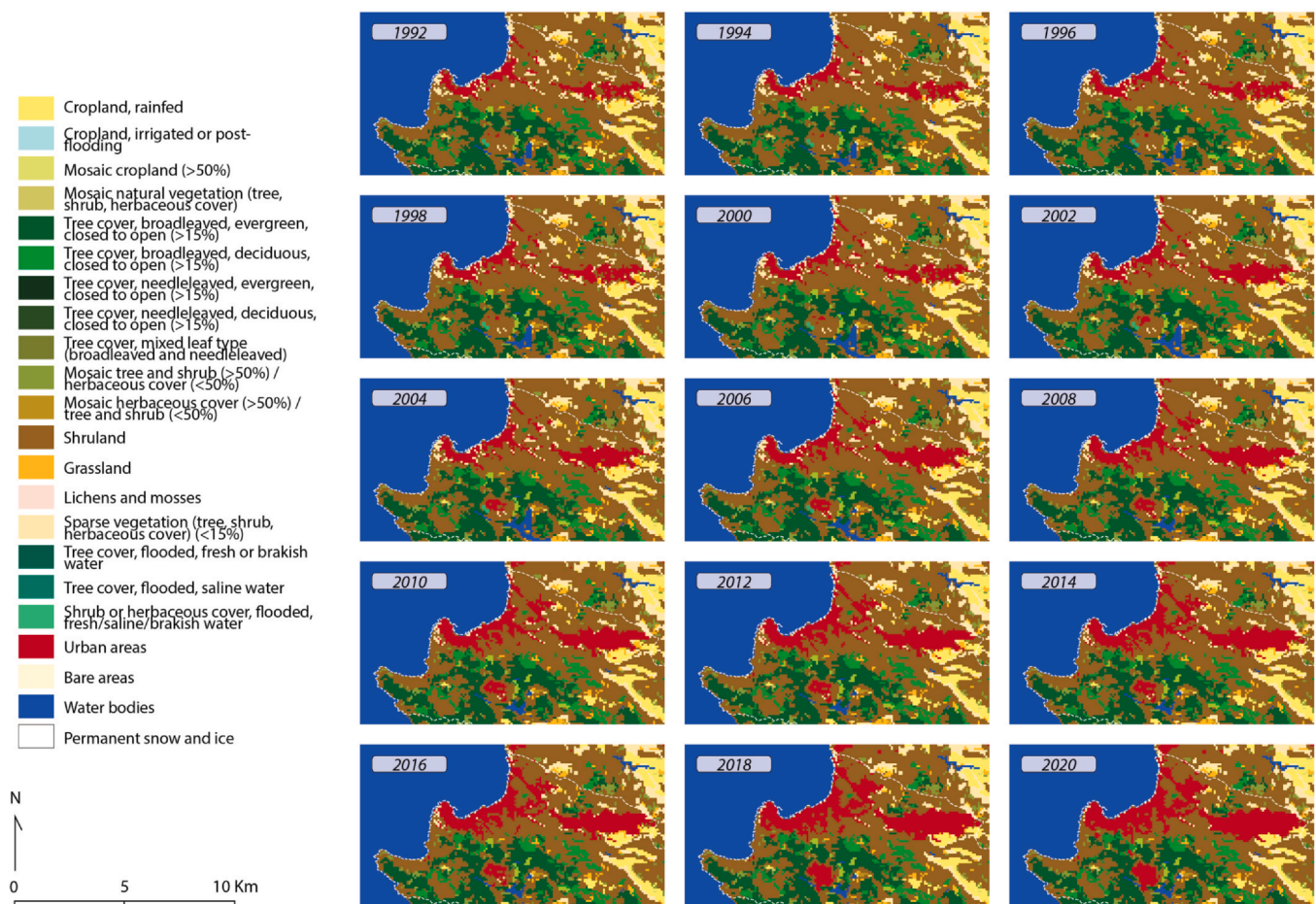


**Fig. 4.** Metropolitan area of Valparaíso (Valparaíso, Viña del mar, Concón, Quilpué, Villa Alemana, Placilla-Curauma, Laguna Verde). Geoprocessing and overlaying different shapefile data using ArcGIS Pro (Esri). Data collected from USGS (<https://earthexplorer.usgs.gov/>) and IDE Chile (<https://www.ide.cl/>). Source: By the author.



**Fig. 5.** View of informal settlements and their relation with the natural areas. Source: By the author.





**Fig. 6.** Change in land use from 1992 to 2020 focus on the metropolitan area of Valparaíso, presenting an evident expansion in the urban area. Geoprocessing of rasters using ArcGIS Pro (Esri). Data collected from Copernicus Climate Change Service, Climate Data Store (<https://maps.elie.ucl.ac.be/CCI/viewer/index.php>). Source: By the author.



**Fig. 7.** Colossal urban fire. (a) Wildfire Valparaíso 2014; Source: Alberto Miranda San Martin (Yunis Richter, 2022). (b) Wildfire Laguna Verde 2017; Source: By the author (Yunis Richter, 2022). (c) Wildfire Viña del Mar 2024; Source: Martin Thomas, Aton Chile (Associated Press, 2024).

Regional Metro (MERVAL)<sup>7</sup> and highways] conforming the metropolitan area of Valparaíso (Fig. 6). The ongoing urbanisation, especially in hilly and ravine areas, mainly occurs through self-organized development corresponding to the informal development, including the building of roads and infrastructure within. These elements lead to a decline in natural spaces, pollution of soil and water bodies, and a decrease in ecosystem services. Consequently, the ravines, which are important natural features and contribute to public spaces, are relegated to remnants of urban expansion, and are deemed critical from an ecological perspective.

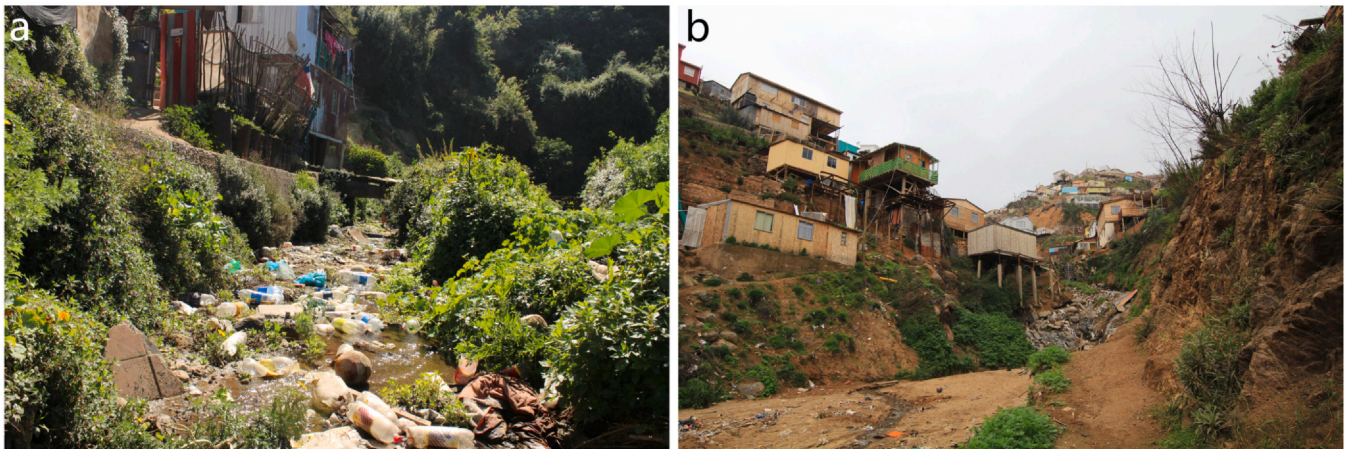
The consequences of the phenomenon of urban sprawl in the basin and the unprecedented intensity with which it took place, gave way to a substantial change in the structure and functionality of urban

ecosystems, which, while threatening the resilience of these territories, increases the levels of environmental degradation, segregation, and cascading risks (Tsoutsos, 2023), calling into question the stability of the current model of socio-spatial reproduction (Mansilla, 2000). In this sense, the sectors most disadvantaged by the dynamics of urban segregation tend to be concentrated mainly in the city's periphery (the hills and ravines). They are the ones who deal daily with the socio-environmental injustices caused by the existing urban reproduction (Martínez, 2014).

In Valparaíso, informal urban development expansion is the highest in the Chilean central region (2024). This is due, among other causes, to the difficulty for the poorest population to acquire land or housing and the insufficient housing coverage provided by government plans and programmes. These factors not only exacerbate socio-spatial segregation and favour the increase of this habitat but also force many people to assume significant risks to access a place in the city (Martínez, 2014).

<sup>7</sup> MERVAL: Metro Regional de Valparaíso.





**Fig. 8.** Condition at the interior the ravines. Presence of waste in the watercourse (a) and informal settlements (b).  
Source: By the author.

The urban sprawling of the city of Valparaíso to risk areas, expressed with greater emphasis on the occupation of ravines, is also a determining factor in the impossibility of recovery for lower-income social actors faced with some disaster (earthquake, wildfire, landslide, among others), and who find in the taking of land a viable and rapid housing option in an emergency context after a catastrophe (Pino et al., 2013).

The phenomena described above reinforce the threats of natural origin inherent to the territory, adding others of an anthropic and socio-ecological nature, as occurred in 2014 with the colossal urban fire in the city of Valparaíso or those following this, such as the wildfire in 2017 in Laguna Verde (southern coastal area from Valparaíso) or the case of Viña del Mar 2024 (Fig. 7), together with other events that had happened in the different seasons (droughts, floods and landslides) for put some examples.

The environmental deterioration produced by unplanned urbanization on the territory, the degradation of streams and natural systems within Valparaíso, is a multidimensional and complex conflict, particularly in contexts where the city has turned its back on them or has excluded them in its urban and landscape recognition.

Traditionally, the planning values and methods on the Chilean cities, have been based on the hygienist paradigms that strongly influenced the development of the city of Valparaíso (Álvarez, 2001; Seguel Medina, 2024) oriented to increase the drainage capacity by decreasing its roughness, hiding the waters coming from the streams, covering it or diverting it with the only objective to resolve the city's sanitary condition, neglecting the fauna, the flora, the ecosystemic services it offers and its landscape quality. Among the causes of the deterioration of these important natural elements located within the urban limits because of the expansion of the city are the following reasons (Fig. 8):

- (1) The dumping of solid and liquid waste transforms the interior of the ravines into sewers.
- (2) The destruction of natural and semi-natural habitats adjacent to the axis of the stream due to the extension of informal residential activities.
- (3) The reduction of water flow due to extraction and use for private purposes and introduced species with high water consumption reduces the capacity to maintain the ecological flow.

Under the above paradigm, currently, Valparaíso presents a complex urban scenario requiring an integral and comprehensive approach that considers multiple areas of knowledge, systems, and scales. Understanding the problem of integrating the city and its natural elements as a problem that involves explicit recognition of both the ecological services and goods they provide to society and the natural risk factors involved.

The necessity of recognized and integrating the landscape as a basis in the current spatial development model, integrating socio-ecological

variables and the city's intricate geomorphology and incorporating them, is a key element to generate practical design knowledge to support urban planning and design processes. In this sense, the condition of the ravines as a natural element close to the consolidated city emerges with enormous socio-ecological potential as a container of natural habitats and visual references, constituting an area for the formulation of strategies that enable the integration of natural systems with the city, going from being marginalized spaces to being critical elements in terms of social activities and ecological dynamics within the city. In this way, the ravines will go from being a tangential, secondary, and even threatening element to becoming a resource for urban recovery and landscape resilience from an ecological, social, and cultural point of view.

### 3. Landscape as an alternative approach

Urban sprawl and climate change have led to biodiversity loss, habitat fragmentation, increased hazards (droughts, floods, wildfires) and uneven access to ecosystem services (Schuster-Olbrich et al., 2024). These issues heighten risks for populations and ecosystems, exposing patterns of negative externalities in urbanisation that affect vulnerable areas (Martinez, 2014). In this context, the historical absence of institutions, instruments, and practical knowledge for designing and planning in Latin American cities has resulted in specific forms of landscape degradation and unsafe conditions, amplifying risks to the territory. The importance of integrating the landscape in urban planning and design is a current study that has gained relevance since the 1960s due to the limited capacity of the urban project to respond to the climate crisis. This aspect was declared by Ian McHarg (1969) from the critical view of man's actions when relating to his environment, bearing in mind what happens during the transition from a natural landscape to an artificial landscape. Situating ourselves in the scenario of environmental conflicts in the contemporary city, studies such as landscape ecology and urbanism and even a critique of the more traditional urban design become relevant today.

The understanding of this natural factor within landscape theory determines its importance, which had been considered by several authors such as Ian McHarg (1969), Charles Waldheim (2006), James Corner (2006), Mohsen Mostafavi (2010), Carl Steinitz (2012), Anne Whiston Spirn (2014) and many others, studying the territory in a systemic, dynamic, and multiscale way in the form of an "Ecological Inventory". This corresponds to the superposition of natural, social, and urban layers that contain diverse information such as geology, land use, aquifers, vegetation, wetlands, rivers, slopes, social values, and heritage so that the intervention is integrated into the territory in a complex manner.

Most authors focus primarily on ecological variables in their research, using the concept of “Ecological Inventory” to understand specific territories. However, there is a notable gap in these frameworks when it comes to addressing social aspects, particularly regarding informal settlements, which are prevalent in many Latin American cities. While the ecological component is essential, especially in regions rich in biodiversity like the “Tropical Andes” and the “Chilean Winter Rainfall Valdivian Forest,” some of the few biodiversity hotspots<sup>8</sup> in Latin America, these areas are continually threatened by social processes. The disregard for natural elements, as well as the complex geomorphological conditions and socio-ecological variables in the planning and design process, has intensified the contradiction between the support provided by nature (ecosystems) and the socially constructed environment (the city and its physical infrastructure, socio-spatial practices, cultural patterns, etc.); in other words, degradation encompasses and integrates the entirety of the landscape: the natural, the physical (urban), and the social.

Michael Hough (2004) emphasizes that the traditional values of the physical planning of cities have contributed too little to environmental health, so it is important to find a way to treat the urban landscape in harmony with nature dynamics. However, nowadays, cities are shaped by technology, whose main purpose is economic, leaving aside social and environmental aspects. In terms of the urban planning of existing cities, Michael Hough argues that the disciplines responsible for planning them have too little education in terms of natural science to understand the ecological values involved in incorporating them. As a result of the construction of cities, two types of interacting landscapes have been generated. One is the urban landscape, which is experienced through its streets, layout, public spaces, and diversity of other uses. At the same time, the secondary one belongs to the ignored landscape, such as the railway, wastelands, or ravines.

These two landscapes, formalist and natural, symbolize the conflict in planning according to environmental values, the former having little connection with the dynamic processes of nature, while the latter represents its vitality. There are different ways of conceiving how cities are designed and evolve, what are the priorities and culture for this, and practices that have changed in favor of the defense of the environment and biodiversity as a new way of understanding the development of people and the planet in a global way, in which they increasingly occupy a space in the discourse of architecture, urban design, and territorial planning, linking it directly to the landscape.

Understanding the interplay of complex physical and social factors at different levels is crucial (Billi et al., 2021). This means we need a holistic approach that combines environmental considerations and cultural aspects to create a healthier ecosystem by effectively managing land and water resources. This foundational work is vital for developing resilient green and blue spaces that lead to sustainable cities and reduce their environmental impact (Nijhuis, et.al, 2023). The diversity of spaces for the development of landscapes in the city allows for an improvement in the quality of life for the inhabitants and its ecosystems. These spaces must be varied and interconnected so as not to cut off the environmental processes and dynamics that they have in themselves. This diversity must have both a social and ecological role in the city so that the requirements can have a mixture and greater stimulation of varied elements in the landscape.

Taking the landscape as a basis (Fig. 9) is not merely cognitive, aesthetic, or symbolic but dynamic environments where natural systems, built structures, and human activities interact. They emerge from the balance of these forces shaping the territory (Zonneveld, 1995; Nijhuis, 2024). This perspective offers a comprehensive understanding of the diverse systems and interactions at various scales, which is



Fig. 9. The natural landscape as a base for social and economic development. Source: Stockholm Resilience Centre, Stockholm University, 2018 (Stockholm Resilience Centre, 2018).

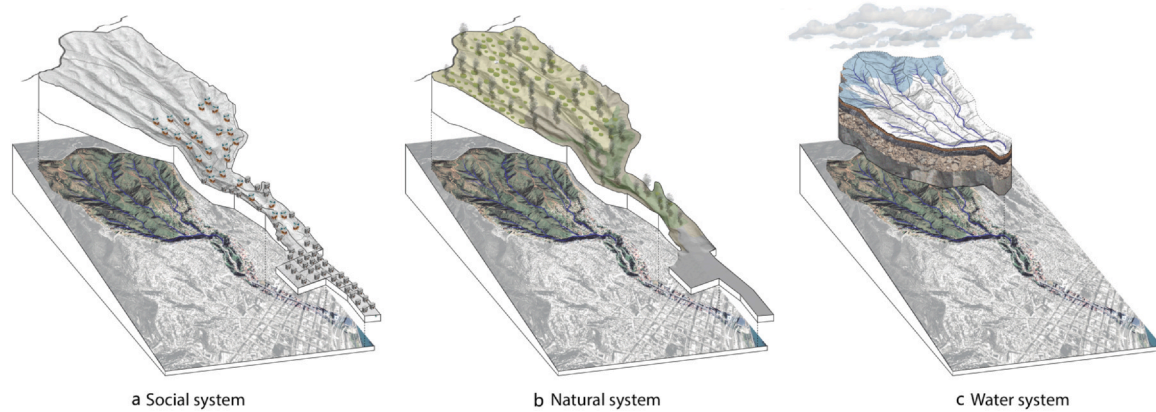
crucial for developing green/blue infrastructure. However, just as the landscape as an approach can be defined as a set of relationships between natural and cultural factors, these are also determined by economic dynamics that result in a functional urban landscape reflected in metropolises, revealing the lack or need to give value to the *latent landscapes* (Nogué, 2007).<sup>9</sup>

With the recognition of the geomorphological condition and the socio-ecological variables, as a basis to favor the correct development of practical knowledge for the planning and design of the territory and also to facilitate the integration of threatened landscapes to safeguard their biodiversity, it will allow the integration of the urban and the natural in conditions that enable the development of both; ensuring that nature is not only preserved but also prioritized for the development of the social and economic system (Nijhuis, 2022). A landscape-based approach presents an opportunity to strategically enhance adaptive and resilient areas at community, regional, and national levels, serving as a crucial pathway for integrating actions toward sustainable development.

In summary, landscapes are a fundamental physical and ecological foundation, integrating biodiversity, sustainable water systems, and essential ecosystem services in which a landscape-based approach offers a valuable opportunity to deepen the understanding of various factors that shape the territory. Considering the physical landscape structure and its connection to natural and social processes, this approach system provides key opportunities for protecting and conserving biodiversity, supporting the water cycle, and integrating ecosystem services.

<sup>8</sup> Hotspots are understood as highly threatened and at-risk sites, in need of protection and global priority for conservation. Critical Ecosystem Partnership Fund (CEPF). (2019). A Lifeline for Biodiversity.

<sup>9</sup> Latent landscape: A proposition made by the author Jean Nogué in his text “The social construction of Landscape” refers to a historical and hidden state of the place located in the memory of the settlers that has been replaced by human decisions of the present.



**Fig. 10.** Taking the geomorphology as a support for (a) the social system conformed by the formal city and the informal settlements, (b) the natural system is structure by native vegetation and exotic vegetation and (c) the water system is structure in three forms of water recharge: seasonal rainwater recharge from streams, the water in suspension coming from the coastal *vaguada*<sup>10</sup> and the subsoil by its infiltration system.

Source: By the author.

#### 4. Toward a landscape-based approach for Valparaíso

Natural fragmentation is recognised as a significant concern for ecosystem integrity and the reproduction of risk scenarios (Laforteza et al., 2018). Valparaíso has the potential to become a hub for green spaces that enhance the environment and promote community engagement. By emphasising environmental education, these green areas could help combat ecological degradation. When people have access to parks and natural spaces, it encourages interaction among neighbourhoods, fostering a sense of connection with the environment. The recognition and integration of natural elements—such as the Chilean matorral ecosystem—alongside complex geomorphological conditions, including steep coastal valleys and sensitive groundwater systems, and socio-ecological dynamics, such as informal hillside settlements present in the ravines and the inhabitants who live in these places (Fig. 10), are not considered now of planning, management, and design of the territory.

In response, an integrated approach is necessary to guide socio-ecological processes and geomorphological configurations to understand the natural dynamics of the territory and integrate, propose, and construct practical design knowledge helpful in planning and designing for projecting a safe, resilient and adaptive landscape to the ecological and social degradation of cities.

A paradigm shift towards a landscape-based approach is essential to tackle this issue (Seguel Medina, 2024). This perspective could integrate territorial variables and geomorphological conditions to alleviate the residual status of the ravines and contrasts sharply with the current urban development model. Recognising and incorporating geomorphological and socio-ecological factors into planning and design processes can improve the city's adaptability and landscape resilience. To address this, the research is separated in two aspects: 1) The objective, which is to understand the aim of this research; and 2) the methodology and methods used to achieve the objective.

<sup>10</sup> Coastal Vaguada (in Spanish Vaguada costera): An area of low atmospheric pressure on the surface off the central coast of Chile, moving eastward, forcing air masses to descend from the western Andean slope. The coastal trough consists of two stages, the first phase South-East, determines that the air flows from the East, descending from the mountain range towards the West, intensifying the thermal inversion layer and bringing it closer to the surface, affecting the region with clear skies and pleasant temperatures. The second north-westerly phase affects the area with moist air from the coast, cloudy with dense fog and low temperatures, improving ventilation conditions and ending its passage. [Glosario del Aire. (n.d.). ASRM. Retrieved April 8, 2025, from <https://web.archive.org/>].

##### 4.1. Research objectives

This research aims to develop a landscape-based, multi-scale design and planning framework that responds to Valparaíso's complex ecological, geomorphological and socio-spatial conditions—including the Chilean Mediterranean “matorral” ecosystem, steep coastal valleys, informal hillside settlements, and sensitive groundwater systems. The research will generate planning and design knowledge through the development of 1) context-specific ways of understanding, 2) indicators, and 3) practical design principles and strategies, supporting adaptive and inclusive planning in fragmented socio-environmental systems—both in Valparaíso and in other urban development hotspots along the Andes range (Fig. 11).

Considering the geomorphological condition as the support and the socio-ecological variables as a basis when planning and designing a territory, offers an understanding of the natural dynamics of the territory and the capacity of communities to interact and cooperate, in the face of a threatened or damaged landscape to make a resilient territory over time. The forecasted result focuses on the connections between geomorphology, ecology, and society and how these three elements contribute to the functioning of a territory, city, and natural system. It highlights nature's important role in providing for, enriching, and shaping the urban landscape. These elements are associated with ecosystem services, which allow an assessment of the natural, cultural, provisioning, and sustaining assets that nature provides to the urban habitat (Millennium Ecosystem Assessment, 2005).

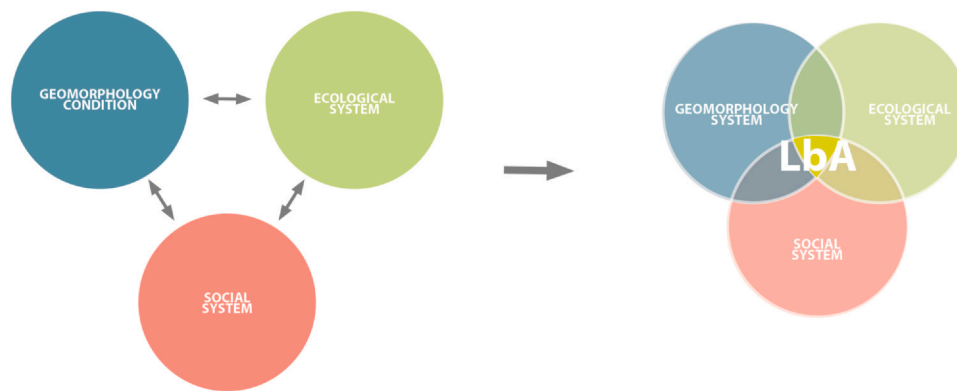
##### 4.2. Methodology

While a landscape-based approach acknowledges these complexities mentioned above, it cannot be effectively addressed by individual or specialised knowledge alone. A design-related research opens the opportunity as a methodology that will make it possible to incorporate different types of expertise and work on various scales, offering an integrated means of developing answers to questions (Nijhuis, de Vries, 2020).

According to Nijhuis and Bobbink (2012), design-related research has two domains (design research and research-by-design) that cannot be seen apart from each other. Each domain has two modes where the process is developed: (1) design research: plan analysis and comparative analysis, and (2) research-by-design: experimental design study and design study. In this sense, to determine the scope of future practical design knowledge, design-related research offers vast opportunities.

In this research, both domains of design-related research have been employed. In the first phase, plan analysis is implemented to gather territorial and local information and specific knowledge for getting





**Fig. 11.** Recognition and integration of the geomorphology and socio-ecological variables through a landscape-based approach (LbA). Source: By the author.

indicators and propose future matrixes. In the territorial scale, it will develop data collection and multivariate analysis using GIS software to construct a series of maps and the elaboration of geoprocessing intended to be used as reference material to support the formulation of a methodology for adaptation strategies in the physical and phenomenological context. At the local scale, it will develop a Landscape Characterisation Assessment considering four criteria (Biophysical, Anthropic, Socio/Cultural and Aesthetic) to understand the particularities of the territory between what we get from the GIS analysis and what we get from the pedestrian perception.

The second phase is a comparative analysis where the focus is on understanding the state of the art regarding urban/natural landscape, green/blue infrastructure and adaptive and resilient landscapes to provide an overview of principles and strategies. An inventory will be created through bibliographic material based on a compilation of references and the data collected from the fieldwork, understanding the context from its ecological and social systems, and considering the previous analysis, also the study of international cases will be developed to provide a more objective view of good practices for what is suitable to implement.

The third phase will be the development of preliminary practical design knowledge in the specific context (design exploration). A process of co-design with communities and stakeholders could reach and propose alternatives for the restoration of the ravines, based on their potential as ecological corridors that articulate urban functions, acting positively on the diagnosed urban deficit by defining their programme, actions over time and their scope of management.

And the last phase consists in the optimisation of the design by iterating (design process). The results of the design studies and the applications of practical design knowledge will be adjusted and validated by GIS modelling to assess how the guidelines and principles would develop over a longer period of time as a long-term perspective. In addition, the design process will be reviewed and diagnosed by peers and experts who will assess the applicability of the design principles within the Valparaíso context and the collaborative work with the communities as part of the design process (learning together).

Although the intention of the design principles originates from a place-based and situated knowledge solution that considers the socio-ecological variables and geomorphological conditions of Valparaíso, the issues associated with environmental degradation, socio-spatial segregation, and related risks are not unique to this location; rather, they are broader problems at the regional, national, and continental (Latin America) levels. In light of this, translating specificity into broader practical design knowledge can operate with complexity between urban and environmental relations in other contexts, particularly regarding functional supports adapted to natural dynamics and urban uses, which serve as elements capable of recovering the benefits of natural spaces integrated into consolidated urban areas.

## 5. Results

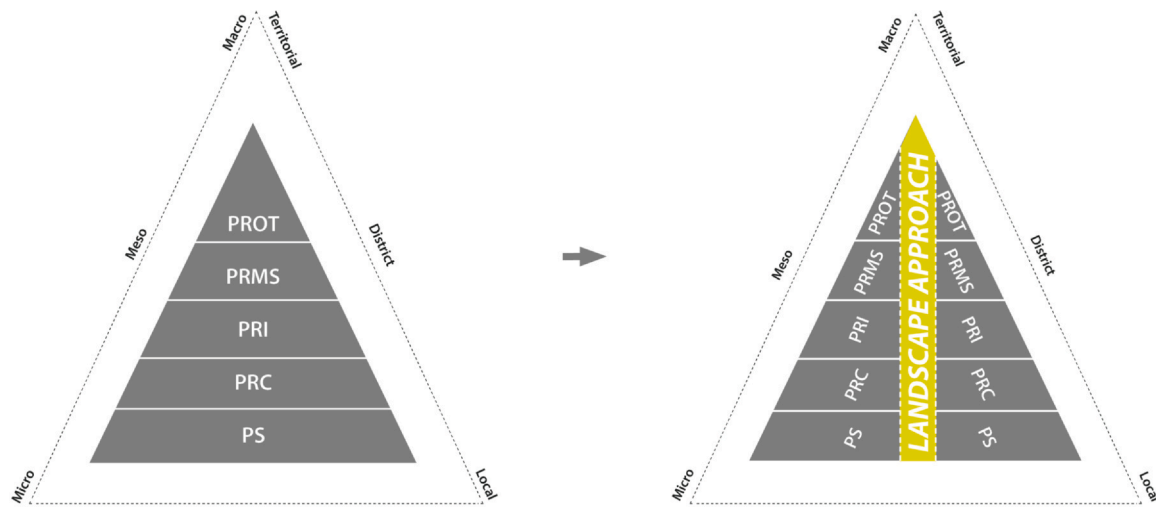
A landscape approach, with a long-term territorial vision, is necessary to link urban systems with environmental and cultural dynamics. On one hand, planning guidelines should be developed to facilitate discussions and agreements among different stakeholders, including communities, municipalities, local governments, and ministries, at various scales (Fig. 12). On the other hand, the ravines, which shape the public spaces of Valparaíso, offer a unique opportunity to establish a network of green and blue infrastructure within the city through the implementation of short-term interventions related to pilot projects involving the communities that live in these sensitive areas (ravines) through local knowledge and practices that they can provide and revealed the importance of their territory and their relationship with it. This network would facilitate connectivity between open spaces and enhance mobility between hills and ravines. By strengthening socio-ecological variables, the degradation of these natural corridors can be reversed, transforming them into platforms for public recreation, fostering connections between neighbourhoods, and enhancing ecosystem services while simultaneously linking urban areas with the surrounding natural landscape.

Rather than prescribing fixed design outcomes, this approach proposes a comprehensive, basin-oriented perspective that positions ravines and other natural systems as key agents in the spatial design and planning of the city. By recognising their geomorphological condition and ecological and social significance, this framework enables the articulation of place-based guidelines and principles that respond to both the physical complexity and social realities of the territory. Some of the preliminary future implementation associated with the strategic guidelines across the scales area operates across two spatial-temporal axes:

- (1) Long-term strategic planning: Through the reinforcement of green/blue infrastructure networks connecting ravines, watersheds, and hills; Zoning protections for ecological corridors; and integration of geomorphology and socio-ecological systems into planning instruments to guide land-use decisions based on ecology, hydrology and social dynamics.
- (2) Short-term community interventions: Through pilot projects in selected ravines, to test the reforestation process, ecological restoration, and guidance of informal settlements. Collaborative design practice that incorporates local knowledge into the co-production of public spaces, and environmental education programs to promote awareness at the neighbourhood scale.

Adaptive and resilient planning and design are linked to the idea of strengthening natural systems (green/blue infrastructures) in the hope that inhabitants will integrate and understand the systemic character of





**Fig. 12.** Integration of the landscape-based approach as an integral framework of discussion in the different territorial planning instruments (Chile), from the local to the territorial scale. PS: Sectional Plan (Plan Seccional); PRC: Communal Regulatory Plan (Plan Regulador Comunal); PRI: Intercommunal Regulatory Plan (Plan Regulador Intercomunal); PRMS: Metropolitan Regulatory Plan (Plan Regulador Metropolitano); PROT: Regional Territorial Planning Plan (Plan Regional de Ordenamiento Territorial).

Source: By the author.

natural landscapes through the provision of places where people value and connect emotionally.

This exploration is not far from recent international efforts to address climate change, which no longer only seek to respond to mitigation through a “grey” infrastructure but also from adaptation through interventions that are more closely related to nature. Practical design knowledge based on a landscape approach seeks to work with ecology and social variables, as well as a series of actions such as protecting, restoring, and sustainably managing ecosystems to enhance the natural and social environment. Broadly speaking, the guidelines and design principles aim to adopt an alternative, non-traditional approach to environmental problems by understanding socio-ecological variables and the complex geomorphology, with the goal of informing land and urban planning and design.

## 6. Discussion and conclusions

As discussed, Valparaíso’s urban landscape is shaped by a complex interplay of geomorphological conditions and socio-ecological systems, many of which have been deeply fragmented by unregulated urbanisation, insufficient territorial planning, and a lack of environmental management. The absence of an integrated vision has allowed the unchecked development of informal settlements, the degradation of critical natural areas, and the progressive atomisation of ecosystems, particularly across the city’s hills and ravines. These processes have not only disrupted ecological continuity but also exacerbated socio-ecological vulnerabilities and increased risks within the urban fabric.

In response, the present paper, along with associated research, pursues a landscape-based approach as a strategic and inclusive framework for guiding the adaptive transformation of Valparaíso. Such an approach and results fosters multi-actor and multi-variable collaboration across disciplines—including urban planning, landscape architecture, and environmental science—and promote a shift in urban policy toward ecological integration and resilience. As a design strategy, it links long-term ecological objectives with short-term urban interventions, bridging the gap between regional planning and local actions. This is particularly crucial in Valparaíso, where the dynamic relationship between geomorphological conditions and socio-ecological factors calls for adaptive measures tailored to the local context (Rosati et al., 2015; Schipper, 2020).

Valparaíso, as Chile’s principal port city, exemplifies the intricate urban conditions that arise from development in complex

geomorphologies. Its unique terrain not only highlights the challenges posed by such environments but also reveals opportunities for broader regional application in the Chilean context, but also these lessons could inform similar interventions in cities with comparable conditions in Latin America, such as urban agglomerations in coastal areas of Perú, Colombia, and Ecuador, among others, where not only is the presence of the geomorphology from the Andes range, but there is also a richness of biodiversity associated with this natural feature, as well as informal settlements established in high-risk areas as an urbanisation challenges.

By envisioning ravines as connective ecological corridors—integrated through green and blue infrastructure—planners, designers and policymakers can reimagine these spaces as vital public assets (Donati et al., 2022). This strategy promotes recreational use, improves intra-urban connectivity, and strengthens the delivery of ecosystem services, ultimately linking the urban environment to its surrounding natural systems and enhancing overall landscape resilience. Moreover, the integration of green and blue infrastructures—through the connective tissue of a green/blue network—further reinforces the territory’s resilience (Chatzimentor et al., 2020). These infrastructures are not simply additions to the urban realm but are reframed as essential structural systems that support ecosystem services, climate adaptation, and social well-being. When recognised as active agents in urban transformation, natural features such as watercourses, ravines, and forest remnants evolve from marginalised spaces into multifunctional assets that contribute to a more inclusive and sustainable city (Giannotti et al., 2021).

In summary, a landscape-based approach brings new operational capacity to spatial design in Valparaíso, contributes a context-sensitive interpretation of landscape urbanism tailored to the Global South, where formal planning is often lacking, and ecological degradation intersects with poverty and informality. Unlike traditional landscape frameworks that emphasise aesthetics or are focus in the ecological role, neglecting the social aspects, this approach foregrounds the productive potential of situated-based knowledge in neglected landscapes, particularly ravines, as spaces of resilience. Providing a framework for measuring and responding to the territory’s dynamic performance, encouraging the development of practical design knowledge that is both grounded in local realities and scalable across spatial and temporal dimensions. As an integrative and forward-looking method, it positions the landscape not only as a backdrop to urban life but as a fundamental driver of socio-ecological transformation—linking natural processes with human aspirations, and forging pathways toward sustainable, adaptive, and emotionally resonant urban futures.

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## CRediT authorship contribution statement

**Cristian Seguel-Medina:** Writing – original draft, Visualization, Investigation, Data curation. **Steffen Nijhuis:** Writing – review & editing, Validation, Supervision. **Diego Sepulveda-Carmona:** Writing – review & editing, Validation, Supervision.

## Data availability

The original contributions presented in the study are included in the review; further data inquiries can be directed to the corresponding author.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Cristian Seguel-Medina reports financial support was provided by Innovation and Development Agency of Chile (ANID). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Given Prof. Steffen Nijhuis role as Associate Editor of this journal, he was not involved in the editorial review or the decision to publish this article and had no access to information regarding its review.

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