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Green Infrastructure Systems Facing Fragmented Cities in Latin America - Case of Santiago, Chile

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Abstract

Reaching a balance between the protection of nature and the satisfaction of multiple social needs within highly dynamic metropolitan contexts - such as that of Santiago, Chile - is probably one of the main challenges facing territorial planning. This paper presents the progress made in the recognition of the green infrastructure system in Santiago, Chile and reflects on the opportunities and challenges for the development of a green infrastructure system to face socio-ecological fragmentation in Santiago.

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Keywords: urban segregation; green infrastructure; dynamic urban development; Santiago de Chile;

1. Introduction

During the last decades, the urban growth in Latin America has produced fragmented cities, with increasing levels of social and urban segregation [1]. At the same time, the highly dynamic urban development has created conflicts with the protection of nature, due to the necessity to satisfy multiple social needs. Reaching a balance between these factors is probably one of the main challenges of territorial planning.

Santiago, the capital city of Chile, is the 7th largest major city of Latin America with almost 8 million inhabitants and by far the largest and important city of Chile, since it concentrates 42.7 % of the Growth Domestic Product and 40.3 % of the national population (in 2006) [2]. As a consequence of this high demographic importance and economic

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dynamics, Santiago has almost doubled its size during the last thirty years, from 34,792 in 1975 to 65,543 ha in 2004, replacing previous agricultural lands, native forests and shrubs with urban land uses and occupying river beds and streams [3]. These land-use and land-cover changes have had dramatic environmental consequences.

The mentioned urban dynamics produced a city in constant collision with the natural system, including negative impacts on the state, structure, and flow of matter and energy characteristic of the dominant geographical conditions. This structural disarticulation produces many environmental problems such as an increase of sealed surface and consequently of atmospheric temperatures, an accelerated disappearance of vegetated areas, a major interruption of wind/ventilation corridors, of sediment and water flows, and finally, increasing exposure of the local population to environmental hazards.

All problems mentioned above put the long-term environmental sustainability of Santiago into question and point out the urgent need to restore and improve the link between natural and socio-urban systems. This necessarily involves recognizing and properly valuing green and open spaces that provide critical environmental services in urban environments [4]. Maintaining a green infrastructure interconnected network of proper functional ecosystems based on key landscape elements —such as wetlands, forests, creeks, lakes, rivers, and others— would ensure the provision of ecosystem services (ES) aimed at preserving or restoring landscape integrity [5]. If compared to approaches based on the conservation of vast regions in highly dynamic environments, the elaboration of an approach to land planning based on the planning and conservation of an essential network of green spaces intended for territorial cohesion would render highly effective and efficient results.

This paper presents the general identification of green key components within the metropolitan landscape of Santiago and the assessment of a set of ecosystem services at three spatial levels and reflects on the opportunities and challenges for developing a green infrastructure system to face fragmentation in Santiago. The recognition of different levels of green components and their forms of participation and influence on the regional and urban networks, allows visualizing the actual setting of green spaces of the metropolitan region. This main goal would give the possibilities to plan and model the future green network that the city of Santiago requires to improve the environment and its quality of life.

2. Santiago as fragmented city

The Metropolitan Area of Santiago (AMS) is a conurbation that compromises of 36 municipalities within the Metropolitan Region of Santiago. These 36 municipalities are autonomously administrated by local governments with their own mayor, council, and budgets. There is no administrative boundary defining Santiago of Chile as a city and territorial entity (Fig. 1). Although exist a land use plan concerning the Santiago Metropolitan Area (PRMS, Plan Regulador Metropolitano de Santiago), the design and implementation of infrastructures and public works depend mainly on different ministries and departments, while the local urban regulations depend on the municipalities.

According to Romero et al. [6], urban growth has been characterized by increasing expansion rates with a strong inflexion in 1998. As a result, built-up areas grew from 33,963 ha in 1975 to 61,679 ha in 2009 which means an expansion of 27,716 ha. The city has expanded on all sides, but mainly suffers a strong expansion in the northern areas. This development brings drastic changes in ecological and social dynamics, contributing to urban fragmentation present in Santiago. There are two main land use/land cover change dynamics: (1) the replacement of natural and semi natural vegetation for low density urbanization dominated in the eastern part of Santiago, and (2) cultivate land has been covered by high density urbanization in the southern and western fringes.

Borsdorf et al. [7] developed a model of Latin-American urban development, where it is possible to follow the evolution of Latin-American cities from the compact city distinctive of colonial times to the fragmented city that is well-established nowadays. Fragmented cities emerge as result of global change influencing Latin-American urban development with economic and political changes being the main driving factors. They are characterized by a high spatial and structural complexity. The higher urban heterogeneity and complexity are expressed in an insular or cellular pattern, with urban “islands” associated to (1) micro-commerce and financial centers usually materialized in malls and shopping centers, (2) gated communities for upper and middle classes located in low-income municipalities, and (3) social housing projects poorly connected and informally separated [8]. Santiago has likewise experienced this functional and spatial restructuration through the transition from a polarized to a fragmented city structure. This process has resulted in a decrease of physical distances between areas inhabited by different socio-economic classes,

which consequently produces a reduction of the spatial scale of urban segregation [7], [9]. Nevertheless, in Santiago exist a correlation between the localization of the socio-economics groups and the environmental conditions, concerning aspects such as the distribution of green areas, heat-islands and basic services.

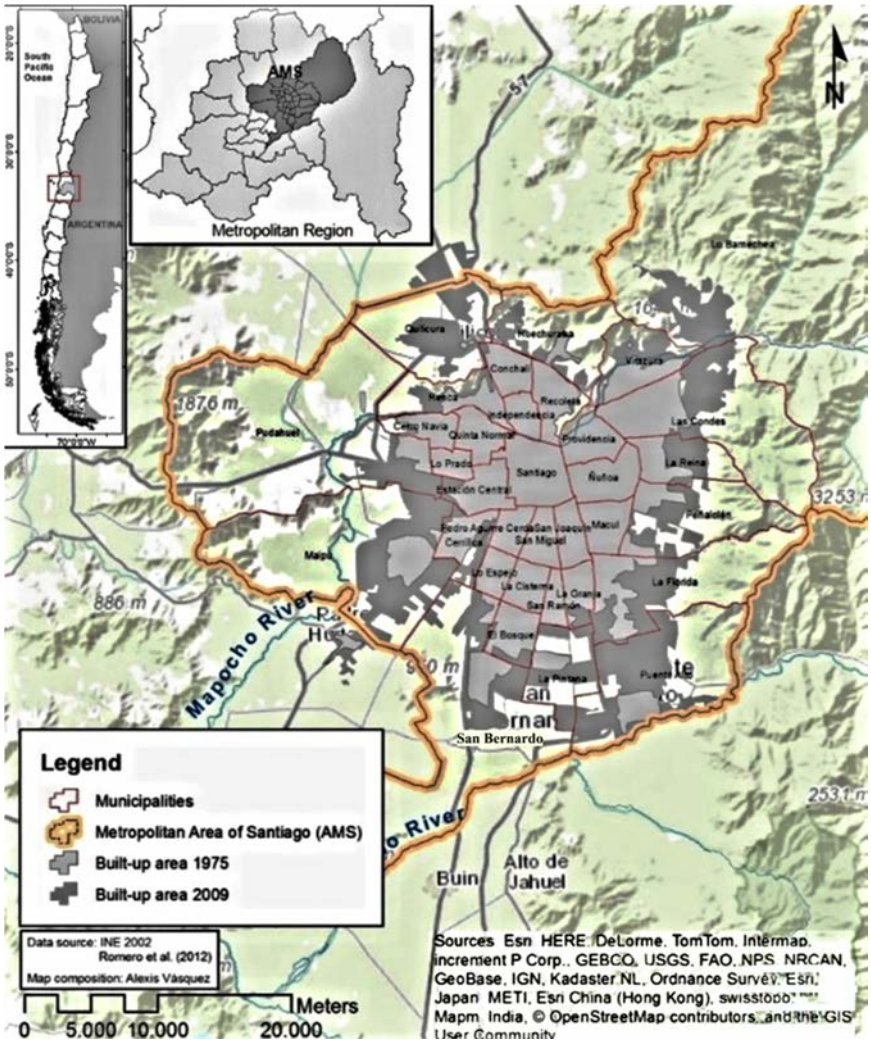

Fig. 1. Administrative boundaries and urban expansion, after Romero et al. (2012).

3. Urban green infrastructure system in Santiago

Green spaces can provide multiple ecosystem services in urban environments. The variety and intensity of the provision of ES are associated with the type of green space [10] [11] and the characteristics of the environment where it is located. However, in general these include the four ES groups proposed by Millennium Ecosystem Assessment [12]. The Table 1 presents a generic list of the main benefits of green spaces in urban environments according to the classification normally used in green infrastructure literature that differentiates between ecological, social and economic benefits.

Assessments of the provision of ecosystem services in urban environments use as analysis unit's different types of green spaces, also named element or type of green infrastructure [11] [13]. The specific types of green infrastructure

present in a given city and suburban environment will depend on the original physical geographical context and distinct dynamics of urbanization. In Santiago, at regional scale these green infrastructure elements are associated with Priority Sites for Biodiversity, Nature Reserves Conservation, Natural Parks, rivers, wetlands, agricultural lands, lakes and remnant forests (Fig. 2). However, urban environments may also include other types of green components of the landscape, that despite being of artificial origin, support important ecological processes.

Examples of green infrastructure components in Santiago at city and local scales are Islands Hills, Metropolitan Parks, university campuses, garden cemeteries, gardens, plazas, parks and irrigation canals (Fig. 2). Green infrastructure components are often classified into a core, nodes and corridor using an approach based on the matrix-patch-corridor model developed in landscape ecology [14]. The cores are ecosystems in good condition and functioning, which support key ecological functions, such as provide habitat for native species, the nodes are land adjacent to the cores that significantly contribute to water purification, flood control, carbon sequestration and recreation of the population, and finally, corridors are linear elements that connect cores and nodes, and are essential to the movement of animals, plants and people [5, 15].

Table 1. Main benefits of green spaces in urban environments, modified after Benedict & McMahon (2006).

Abiotic	Biotic	Social	Economic
Soil development process	Provision of genetic reserves	Better connection to nature and sense of place	Increased property values
Erosion control	Biomass production	Improvement of work and home environments	Provision of material and food
Noise reduction	Habitat for generalist species	Physical recreation	Decreased costs for storm water management
Regulation of climatic extremes	Habitat for specialist species	Improved health	Decreased costs for water treatment systems
Sequestration of carbon	Species corridors	Provide a sense of solitude and inspiration	
Air and water purification	Maintenance of disturbance and successional regimes	Stimulus of artistic/abstract expression(s)	
Maintenance of hydrological regime(s) Surface and ground water interaction Buffering of nutrient cycling	Support of flora and fauna interactions	Experience and interpretation of cultural history Opportunities for healthy social interaction Environmental education	

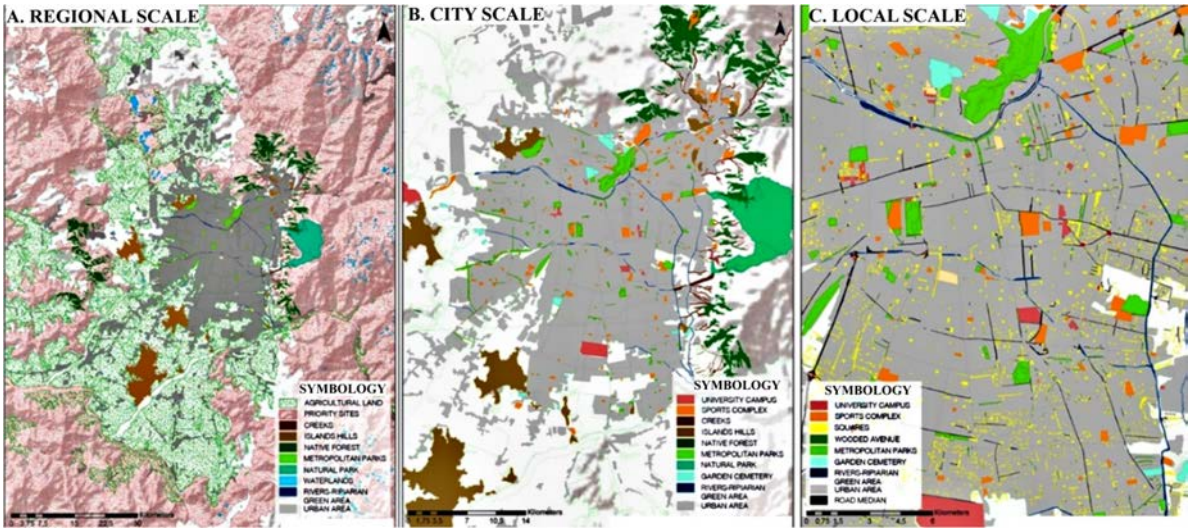

Fig. 2. Green infrastructure system in Santiago at three spatial scales.

In Santiago, most of green infrastructure components can be classified as core and node, and consequently corridors are scarce and not well developed. However, water courses and transport infrastructure offer opportunities for greenway development. In addition to the ecological benefits that imply the different types of green spaces, it is important to consider their origin. Green infrastructure system in Santiago is consolidated by the union of private and public areas. This means building a mixed system that promotes initiatives to establish a structure for planning, conservation and management of green spaces that favour their ecological values. A mixed system should be structured and protected by public policies of territorial planning, as part of urban and regional development.

4. Opportunities and challenges for developing a green infrastructure system to face fragmentation in Santiago

A green infrastructure system is a challenge for the highly fragmented national and regional institutional and regulatory framework. Currently, at the Chilean national level, there are no institutions capable of addressing the complexity of the planning and development of green infrastructure system without review and modernize the actual legal and constitutional framework; this is why coordination among territorial jurisdictions like municipalities and among sectorial authorities like the regional services of different ministries are regarded as a major issue. Santiago´s green components are an actual reflection on inequality and fragmentation that characterize the city. The coordination among different—and sometimes extremely different in their capacities and resources—municipalities is a major issue for the development of green infrastructure system in Santiago. Municipalities, in their capacity of local governments, have a large measure of control and decision over their territories, including the establishment of specific territorial regulations and plans. Such a complexity, together with the laxity of the PRMS, results in different regulating landscape components of Municipal Regulatory Plan (Plan Regulador Municipal, PRC) of adjacent municipal jurisdictions, as in the case of riparian areas; this generates spatial fragmentation and affects the chances of maintaining the spatial integrity of greenways. At a regional level, stakeholders found that regional services of ministries are relevant actors for the future development of green infrastructure system. Although these services are settled in the region, they normally work towards the achievement of national interests and policy goals; this situation hinders partnership cooperation between regional and local institutions and development of a multilevel dialogue.

In addition, these public agencies have different interests and highly fragmented visions. Sectorial policies and regulations have narrow sectorial targets and they are normally developed within an insulated institutional environment, thus causing serious coordination problems. Stakeholders pointed out that this initiative reveals multiple coordination problems not just among ministries, but also between ministries and the Regional Government. This includes different priorities and a lack of coordination of programs and administrative procedures.

Administrative fragmentation existing in Santiago, together with the absence of a major city mayor point to the key role of the regional government in a green infrastructure system. Although GOREs were created in Chile as an effort to promote decentralization, they still do not have enough political, human and financial resources to effectively lead regional development. An example of weak regional governance is the failed Santiago Verde Plan (2006-2011)—proposed and led by GORE—which aimed to increase and improve public green spaces and develop an interconnected network of green spaces at a regional level (including some riparian greenways) through the coordination of municipal and sectorial initiatives. Those involved pointed out that although this plan was relatively well conceived, it basically remained at the conceptual and proposal stages. The free market orientation of urban planning is another major issue that reinforces weak regional governance. This promotes individual and singular initiatives and stresses differences among municipalities in terms of budget, power, human and technical resources. Apart from differences in municipal budget and priorities, the negotiation capacity of privates and ministries for the development of green spaces greatly affects the chances of constructing intermunicipal a green infrastructure system. Moreover, an important determining factor in the development of green spaces it is what happens in the private sector, which are chiefly governed by regulations of land uses. Urban planning not consider the role and environmental quality of the privately owned areas that contribute to vegetated surfaces.

Despite the fact that stakeholders agreed on the great importance of urban green areas, the public and political importance of this topic is not yet enough to become a priority within the urban planning and development in Santiago. However, the public opinion and politicians are becoming aware of the iconic and visual importance of large urban

parks for—especially those located alongside rivers and other key landscape components —for the city and urban inhabitants. The discussion, elaboration and the potential rapid promulgation of the Regional Policy on Green Areas illustrates the increasing political interest in this topic. Other opportunity is related to an increasing number of NGOs concerned about urban sustainable development, urban ecology and urban green spaces. For instance, the Red de Defensa de la Precordillera protects remnant patches of native vegetation in the Pre-Andean area, and Mi Parque and Cultiva develop urban green areas in vulnerable neighbourhoods through a community participatory approach and private donations. The emergence of different NGOs and other related social movements indicate that public awareness about the importance of urban public green spaces is increasing and becoming part of social demands; in this sense, citizens mobilize for collective action in order to protect natural areas or achieve a more sustainable water management.

Local actors have an interest not only for cultural ecosystem services (ESs), but that their interests expand to ESs of regulation and support. This involves a broader and more complex view from actors than the traditional view focused on the aesthetic and recreational benefits of urban green areas. Recognition from actors of a wide variety of ESs potentially provided by green spaces may be associated to the growing political importance of green spaces in Santiago identified by interviewees. The issue of urban green areas has recently become more important in the debate on the quality of life of inhabitants and the development of a sustainable city. Another important aspect is that the idea of a green infrastructure system articulates well with the emergence of new social actors interested in the development of green spaces in Santiago. These groups have diverse interests that range from pro urban cycling and interest in building more cycle lanes, to those who look to promote the historical-cultural heritage of the river, hills and urban forests. These groups of organized citizens can transform into important supporters for developing a green infrastructure system in Santiago that provides them opportunities to meet their demands.

5. Final remarks

The last two decades strive to develop new green spaces have been addressed in the conformation of squares, plazas and small parks by local municipalities, and large urban parks by the regional and national government. Those concentrate the main efforts, leaving as second priority either the conservation of natural areas located especially in the periphery of the city, which have an important ecological value, and the creation of social and ecological connections between green areas.

The consolidation of a future green infrastructure means the generation of green spaces of different scales, with different qualities and functions. Each type of green space is rated in cores, nodes and corridors, based on their spatial characteristics and socio ecological functions. Those categories allow stratification that can specify an operating mode that consolidates environmental functions. However, it is important to achieve the union of the valorisation of the processes and environmental benefits associated with green areas and legal processes that support the creation, preservation and maintenance of these areas.

Santiago has many potentials to consolidate a network of green spaces. Currently urban parks play a major role in this system, because it is currently the focus of political and economic efforts of municipalities and regional authorities. For example, the development of a greenway in the Mapocho River and other water courses could be seen as a major step in the consolidation of a green infrastructure system at a city level, integrating other types of green infrastructure like metropolitan and municipal parks, plazas and other greenways. The configuration of a future system of parks along the main riversides constitutes the potential development of a metropolitan riparian corridor.

This would permit (1) valuing the river as a major urban component in Santiago, (2) taking advantage of the aesthetic and recreational potential of the river in the city, (3) the provision of public green spaces in areas that lack them, and (4) establishing a non-motorised transport route. The development of a green infrastructure system in Santiago can considerably contribute to the social and ecological connectivity and thereby mitigate the socio-ecological segregation and disconnection characteristic of cities in the region. It may also contribute significantly to reconcile urban growth with ecological health and people's quality of life, maintaining functions and key ecosystem services and mitigating

the negative effects of urbanization. Therefore, the establishment of a green infrastructure system can be converted into a key aspect to ensure long-term environmental sustainability of the city of Santiago.

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