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Low-density housing in sustainable urban planning – Scaling down to private gardens by using the green infrastructure concept

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ABSTRACT

Using green infrastructure (GI) concept, urban green spaces in the form of combined private and public green areas with planned and unplanned vegetation, have been recognized as a key element in sustainable solutions for urban communities. For cities, GI provides ecological, social, cultural, technical, and economic functions that also comprise low-density housing (LDH) and its private gardens. LDH can be considered a landscape's ecological matrix that serves as a multifunctional platform for garden-related sociocultural and economic functions. It is composed of technical solutions and processes that reorganize themselves according to residents' ongoing choices. However, the paradigm of sustainable cities argues for the efficient use of space, and LDH may be an inviting area for densification. Infill in LDH increases the number of residents but decreases the space for gardens. Urban planners need to be aware of the potential role of LDH gardens in GI and the pillars of sustainability. This study concentrates on LDH and its gardens in scaling-up approach. First, it reviews some recent studies on domestic private gardens under the pillars of sustainable development and proposes a checklist of sustainable garden characteristics to used by land-use planners. Then it considers possible ways to maintain the multifunctionality of LDH when scaling up to blocks and neighbourhoods.

1. Introduction

Sustainable cities maintain a balance between ecological, economic, and sociocultural pillars. These pillars define planning objectives to facilitate the urban life and residents' well-being, preserve biodiversity, and create economic activity to create jobs, income, and a tax base in cities. Planning for sustainable cities also demands concentration on specific factors such as urban sprawl, energy efficiency, and transportation systems that penetrate all land-use categories by all the sustainability pillars.

Regardless of how sustainability is formulated, there is a demand for practical solutions for sustainable urban planning because urbanization and the world's population continues to increase (United Nations, 2015). After all, cities are considered the most effective solution for transportation, potable water, sanitation services, and electricity (e.g., Wu 2013). Urbanization requires urban planning to determine whether the city sprawls to unbuilt areas or compacts the existing ones. Densification and infill are practical tools used to prevent urban sprawl, and the most effective densification takes place in residential areas that occupy large areas and cover the surface inefficiently.

However, continuous densification decreases the proportion of urban green spaces by reducing both public green areas and private domestic gardens. Some recent studies mention a change in residents' recreational behaviour in densified areas. Arnberger (2012) claims that densification around public green areas might reduce the recreational value of these areas. If a private garden or nearby park cannot provide recreation for residents, they will travel to more distant sites. Sijtsma et al. (2012) found a relationship between the greyness of the living environment and the compensating behaviour of spending more holiday nights away from home. Strandell and Hall (2015) found that a lack of private gardens is related to more intensive use of leisure homes.

Indisputably, urban planning practices need to account for not only the density of residential areas but also other functions that exist there. Residential areas have a diverse system of ecological, economic, and sociocultural microscale functions. This multifunctional scene takes place mainly between the buildings, meaning that if densification and infill are claimed to be a solution for sustainable urban planning, the limits of densification need to be considered in a holistic manner, especially in residential areas.

The challenge for planning practices lies in the conventional nature of these practices that are based on separate land-use categories such as residential, commercial, industrial, and green areas. If urban green

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spaces are defined by these categories, only "municipal" green spaces are included. However, "the total urban green" includes all the vegetation in every land use category. Privately-owned green spaces such as private domestic gardens and the greenery of commercial or industrial plots are a considerable proportion of the total green space system. Total urban green can be defined as the concept of green infrastructure (GI).

GI and its multifunctional approach provide a promising frame to assess micro-functions in residential gardens and yards. Multifunctionality in GI is formed from the holistic integration of ecological, economic, and social influences (Mell, 2008). This approach links GI to the pillars of sustainability. Here, the biophysical dimension of GI concerns vegetation as well as the soil, water, and environment that is required for processes that support vegetation growth and the hydrological cycle. Low-density housing (LDH) as a biophysical platform is a combination of garden-scale micro-functions based on complex and dynamic systems of natural processes, sociocultural networks, and communities.

The objective of this study is to identify the multifunctional scene that private gardens provide for low-density housing and define possible ways to retain its multifunctional nature when scaled to blocks or neighbourhoods in planned LDH. Urban planners need to recognize the potential of this scene as they execute in practice the idea of sustainable and compact cities by planning new developments or densifying existing areas. There is a risk that only the housing's function in residential areas is considered in LDH. This single-function approach neglects cross-cutting functions that are typical premises for contemporary sustainable cities. GI as a representation of the total urban green penetrates all land-use categories.

This study narrows the focus to the biophysical platform of LDH and its gardens to serve as a tangible link to planning practices. This means our approach considers this platform a scene for economic and sociocultural functions and may be unfavourable for them. In terms of ecosystem services, this study concentrates on a biophysical base that provides ecosystem services when functioning properly. However, this approach may exclude some benefits and values (Blicharska et al., 2017).

The following questions need to be answered: What can private domestic gardens in low-density housing contribute to sustainable urban planning in the form of multifunctional green infrastructure? How can these contributory factors be identified in relation to the different sustainability pillars? How can private gardens and low-density housing preserve their multifunctional potential in densification?

2. Materials and methods

We first framed the objective by clarifying the role of the landscape's ecological background in GI and practices in the planning process that affect GI planning. This part describes the nature of top-down concepts and their relationship to low-density housing in the urban settings. Then we reviewed recent garden-scale studies to identify the functions and elements that occur on the garden scale. This review included scientific articles concerning private domestic gardens and yards that originated mainly in Europe, Northern America, Australia, and New Zealand. These studies do not cover all the publications on garden-scale studies, but they aim to demonstrate the nature of the multiple functions that take place in private gardens. The set of previous studies were first analysed based on their essential contents and then freely organised by common topics. Topics, such as a landcover's size or richness, arose as the individual studies were grouped together. Then common themes for titles were developed, and all the titles were categorized under these five emerged themes describing individual gardens: anthropocentric, typologies, surface cover, equipment, and vegetation. Finally, the five themes were arranged by their role in contributing to multifunctional GI and sustainable development: sociocultural, economic, and ecological. Lastly, we proposed a checklist for planning practitioners to recognize garden-scale multifuctionality based on the review and discussed the potential of garden-scale qualities to be scaled-up to blocks and neighbourhoods. This part explored possible ways to maintain garden-scale multifuctionality when densification occurs in low-density housing.

3. Urban Green spaces as a component of sustainable city planning

Urbanization causes indisputable changes in a landscape's physical aspects; however, it also modifies processes involving the landscape such as hydrological systems, biochemical cycles of nutrients and metals, greenhouse gas emissions, and levels of biodiversity in biotic communities (Grimm et al., 2008). Urbanization and land-use changes also generate a new kind of nature (Marris, 2011; Uggla, 2012) and recreate urban-specific habitats like novel and designed ecosystems that are not seen elsewhere.

In sustainable urban planning, it is necessary to combine the built environment and nature into a single entity, where the proportion of green and grey vary and transect through all the different land-use categories. Lindholm (2017) describes this as "green-gray" dichotomy in the context of GI, and she specifically stresses that GI needs to be considered as the entire urban landscape rather than only the public green spaces. Several scientists demand that the polarized man and nature segmentation in the traditional urban land use paradigm be given up. Nature is better understood as socio-environmental arrangements; Cook et al. (2011) describe human-natural systems where multiple social and biophysical processes function on different scales. Naveh (1995) suggests the concept of total human ecosystems where nature and culture interact in a holistic and interdisciplinary way. These studies support considering all urban vegetation (and spaces required to run hydrological processes as well as carbon and nutrient cycles for the growth of vegetation) of man-made, semi-natural, or novel ecosystems in the continuum of urban green spaces.

3.1. Shades of green in the urban context

The widely used "patch-corridor-matrix" (PCM) model developed by Forman and Godron (1986) and Forman (1995) describes the interaction between landscape forms and processes and their relationship to landscape functioning (Francis and Chadwick, 2013). This PCM model represents a landscape pattern in three forms: separated patches, linear corridors, and a matrix as the dominant basic surface. Landscape ecology typically considers patches as places where things live and corridors as connective elements between patches (Matlock and Morgan, 2011). Interest in urban ecology has been focused on patches and corridors, and the outcome of urbanization has been studied from the perspective of habitat loss, fragmentation, and loss of biodiversity (Penteado, 2013). Lately, the urban matrix has become an interesting theme, even if it has been considered the background ecosystem or land-use type (Forman, 1995) or even described with hostility (McGarigal and Cushman, 2002).

The characteristics of an urban matrix are site- and time-specific. In residential areas, the matrix rests on the street grid, private parcels, and the vegetation on them (Ghosh and Head, 2009). The quality of this residential urban matrix differs from industrial or commercial areas because private owners can have a wide range of garden preferences. However, a residential area, as a matrix, provides a major component for GI. The characteristics of urban green spaces in residential areas are based on housing density and the proportion of gardens and permeable (non-sealed) surfaces that allow vegetation growth. Residential areas and their gardens provide a constantly changing urban green that offers a habitat for flora and fauna and the possibility for species movement (Werner, 2011). These new habitats fulfil a function even if they are put to extreme use (Young et al., 2009), but all parts of them might not provide ecological value, such as concrete or asphalt paving and