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Ecosystem Services Perspective in Green Infrastructure: A Literature Review

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ABSTRACT : The concept and application of Green Infrastructure (GI) is promptly becoming world's conservation and planning outline at various level of the development of nations. It is a strategic approach to build sustainable urban development by tackling the current urbanization and over population pressures and problems on urban GI resources, which are the challenges that faces our cities and towns. As a result, GI provides social and ecological responses in the broader sense of the term to help decision makers on the development of urban planning and conservation activity. GI has the potential to achieve sustainability and resilience goals over a range of outcomes in addition to climate adaptation. Therefore, the main objective of this review document is to examine the existing experience of GI planning and development activities using ecosystem services perspective throughout the world. There are a number of articles and publications which are discussed about different perspectives of GI at different level. This paper demonstrates a structured and general definition of GI, which is collected from various authors and list of ecosystem services that can be provided for GI planning and development. The paper also examines different elements that can contribute to GI network in a city by using ecosystem services that can be used by different urban planners in the future as baseline information.

KEYWORDS: *Ecosystem, Green Infrastructure, services, connectivity, natural, sustainability.*

I. INTRODUCTION

Green infrastructure (GI) is relatively new to the vocabulary of urban planning and landscape design. The term was first used in a 1994 report on land conservation strategies by the Florida Greenway Commission [1]. Studies from developed nations showed that GI provides environmental evidence to inform development plan production, as well as serving as a practical means of delivering sustainable development [2]. Therefore, according to [3], GI planning represents a strategic approach to conservation that combines the efforts of previous conservation planning methodologies and practices into a systematic framework that can encompass larger landscapes and broader planning goals. However, there is still considerable confusion and uncertainty about what GI is what value it adds and how it can be achieved and delivered on the ground [2].

The key ideas within the GI literature which are focused on the assumption that green infrastructure can, and does, promote landscape functionality are based on these principles; notions of connectivity between people, places and resources, accessibility to the landscape and the delivery of a range of benefits within an integrated approach to urban-landscape development. Subsequently, GI has been reported as supporting ecological functions, social needs and economic improvements [4] [5] [6] [7] [8] [9].

Thus, this paper is a desk-based review of a number of articles which is conducted in different part of the world and basically focused on GI perspectives of ecosystem services approach at micro and macro level. The aim of this paper is to examine a various literatures of diverse research areas that have various concept and ideas on GI development and management issues in ecosystem services. This paper provide a structured and general definition for GI which is collected from various authors and list of ecosystem services that can be provided for GI planning and development. The paper also examines different elements that can contribute to GI network in a city by using ecosystem services. Therefore, this review document starts by defining Green Infrastructure (GI) in the context of various literature reviews.

II. GREEN INFRASTRUCTURE

2.1 Definitions

The term GI means different things to different people depending on the context in which it is used. Because of this, it has many definitions used by authors working on the concept [10] [7]. Literature shows that, in most academic and practitioner research, the definitions used by an organization or an author relate directly to the focus of their own GI research [11] [7]. For example, conservationist authors may strongly emphasize the ecological and biodiversity components [12], whereas the planners may view the concept in terms of policy implementation [13] [7], and recreational, greenway and GI specialists may focus on the benefits gained through development [14].

Though GI is a term which has grown in use in recent years and the definitions vary from expert to expert, most stakeholders agreed on the following, "GI is a network of multi-functional open and green space in and around towns and cities the gardens, trees, rivers, woodland, parkland, nature reserves and urban wild space, and the access to and through them, which support wildlife and biodiversity, provide recreation, access and leisure opportunities and create a sense of place"[3] [15]. Furthermore, there are common themes which various authors use [7]. Thus, [16] put one definition which provides an insight into the complexity of the GI concept by noting the roles of connectivity, multi-functionality and the development of better ecological, economic and social places across a number of scales as prominent elements of the concept [13] [7] [17].

GI comprises the provision of planned networks of linked multifunctional green spaces that contribute to protecting natural habitats and biodiversity, enable response to climate change and other biosphere changes, enable more sustainable and healthy lifestyles, enhance urban livability and wellbeing, improve the accessibility of key recreational and green assets, support the urban and rural economy and assist in the better long-term planning and management of green spaces and corridors [16].Alternatively, the following table illustrates the various definitions of GI which are provided by different authors at different times.

Table 1: Various Definitions of Green Infrastructure (GI)

Authors (references)	Definitions
[13]	Green Infrastructure is a term that is appearing more and more frequently in land conservation and development discussions across the country and around the world. Green infrastructure means different things to different people depending on the context in which it is used. For example, some people refer to trees in urban areas as green infrastructure because of the 'green' benefits they provide, while others use Green Infrastructure to refer to engineered structures (such water treatment facilities or green roofs) that are designed to be environmentally friendly.
[18]	Green Infrastructure is the network of natural and semi-natural areas, features and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations through the maintenance and enhancement of ecosystem services. Green Infrastructure can be strengthened through strategic and coordinated initiatives that focus on maintaining, restoring, improving and connecting existing areas and features, as well as creating new areas and features.
[19]	The term 'Green Infrastructure' describes the network of natural landscape assets which underpin the economic, socio-cultural and environmental functionality of our cities and towns-i.e. the green spaces and water systems which intersperse, connect and provide vital life support for humans and other species within our urban environments. Individual components of this environmental network are sometimes referred to as 'Green Infrastructure assets', and these occur across a range of landscape scales—from residential gardens to local parks and housing estates, streetscapes and highway verges, services and communications corridors, waterways and regional recreation areas etc.
[20]	GI is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings.
[21]	The physical manifestation of process that connect the built and natural environments, performing multiple functions and yielding associated benefits for the health and well-being of people and wildlife. This perspective links physical

	form and aesthetics with function and outcomes (benefits); natural habitats with landscapes managed by humans for specific purposes; and GI with gray infrastructure. It envisions GI as a 3-dimensional "envelope" that surrounds, connects, and infuses buildings, streets, utilities, and the like.
[22]	GI built on a multifunctional, performance-based foundation that holds the potential to reshape and redefine an aesthetic character that will define the cultural identity of future cities and urban landscapes. GI is also a term for greenways/ ecosystems services-oriented. In the context of developed and developing world infrastructure, urban/green infrastructure can be understood as a continuum from conventional/grey to green or ecosystem services-based. Engineered/grey infrastructure – hybrid/landscape infrastructure – greenways/ecosystems services-oriented.
[23]	GI refers to "systems and practices that use or mimic natural processes to infiltrate, evapotranspirate (the return of water to the atmosphere either through evaporation or by plants), or reuse stormwater or runoff on the site where it is generated.
[5]	GI is define as a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintain natural ecological processes, sustain air and water resources, and contributes to the health and quality of life for America's communities and people.
[24]	GI is a strategically planned and delivered network of high-quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering a wide range of environmental and quality-of-life benefits for local communities. GI includes parks, open spaces, playing fields, woodlands, allotments and private gardens.

a. GI Networks

The other characteristic of GI is that of 'connectivity' and 'value adding' by linking existing green assets and resources. According to [13], GI is our nation's natural life support system - an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America's communities and people. GI is a holistic ecological network system, consisting of a set of natural vegetation, lakes and other areas with known or potential ecological value (hubs) connected by corridors or links [25] [26]. Hubs are argue un-fragmented areas hundreds or thousands of acres in size that contain forest, wetland, and stream systems vital to maintaining ecological health [27] such as parks, reserves and agricultural land. While, corridor or links are the connections that tie the system together and enable GI networks to work [5] such as habitat corridors, greenways and river systems. This concept has its roots in planning and conservation ideas dating back over a century, and includes two important concepts [13]; 1) Linking parks and other green spaces for the benefit of people; and 2) Preserving and linking natural areas to benefit biodiversity and counter habitat fragmentation.

The whole GI network can be used to inform conservation-related land use decisions, if the two primary parts of hubs and links were proactively identified, planned and maintained before development, especially in cities where urban growth has altered even reduced the quality and quantity of green spaces widely [25]. According to [5], the following table describes GI network components and its associated characteristics.

Table 2: GI Network Components and Their Associated Characteristics

Component	Description Of Attributes	Corridors Component	Description Of Attributes
Reserves	Large protected areas, such as national and state parks and wildlife refuges.	Landscape Linkages	Large protected natural areas that connect existing parks, preserves, or natural areas and provide sufficient space for native plants and animals.
Managed Native Landscapes	Large publicly owned lands, such as national and state forests,	Conservation Corridors	Less extensive linear protected areas, such as river and stream

	managed for resource extraction as well as natural and recreational values.		corridors that serve as biological conduits for wildlife and may provide recreational opportunities.
Working Lands	Private farms, forests, and ranches that are managed for commodity production yet remain in a predominantly open and undeveloped state	Greenways	Protected corridors of land managed for resource conservation and/or recreational use.
Regional Parks and Preserves	Less extensive hubs of regional ecological significance.	Greenbelts	Protected natural lands or working lands that serve as a framework for development while also preserving native ecosystems and/or farms or ranchland.
Community Parks and Natural Areas	Smaller parks and other sites at the community level where natural features and ecological processes are protected and/or restored.	Eco-belts	Linear woody buffers that can ease the zone of tension between urban and rural land uses while providing ecological and social benefits for urban and rural residents.

b. Ecosystem Services

In this approach GI emerges from a global perspective in terms of the ecosystem services delivered by nature and natural cycles [28] [29]. These natural cycles operate globally, but can also be retained, restored and maintained within cities to produce local benefits. Historically this perspective is closely linked to the development of the concepts of sustainable development and urban ecology [30] [31]. GI can perform multiple roles in urban areas, for example recreation, biodiversity, cultural identity, environmental quality and biological solutions to technical problems [32]. GI can also be seen as comprising all of the natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales [32] [26]. Significantly, GI can deliver multiple benefits from the valuable urban space it occupies, compared with traditional single purpose engineering infrastructure [33]. It is this character of GI that differentiates it from its 'grey' counterparts, which tend to be designed to perform one function, such as transport or drainage, without contributing to the broader environmental, social and economic context [18].

i. Global Perspectives

The concept of ecosystem services is fundamental to an understanding of GI, and is applicable at range of scales from the global to the local. According to [28], ecosystem services are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services e.g. clean air, water, and food. The concept of ecosystem services has been progressively developing over the last century as a way of distinguishing the dependence of human societies on nature-based systems.[34] defines ecosystem services as *'... the conditions and processes by which natural ecosystems, and the species that make them up, sustain and fulfil human life'*. A growing awareness developed in the 1990s that healthy ecosystems provide goods and services that benefit humans and other life. Work by noted scientists such as Ehrlich, Daily, Kennedy, Matson, and Costanza helped to support this groundswell of environmental awareness [34].

Concern has been growing over the last half century as evidence of decline in the world's ecosystems grows and ecologists, economists and other social scientists debate the underlying socio-economic causes. More than ever before in human history, people living in cities have lost their awareness of their reliance on natural ecosystems for food, regulation of the atmosphere and climate, purification of water, provision of building and raw materials for industry, protection from pests, diseases and extreme weather, and for cultural, spiritual and intellectual stimulation and fulfilment [35].

In response to these concerns the United Nations commissioned a global study called the Millennium Ecosystem Assessment, which was conducted by an international consortium of governments, non-profit organizations, universities, and businesses. The group's report, published in 2005, stated that 'ecosystems are

critical to human well-being, to our health, our prosperity, our security, and to our social and cultural identity' [36]. Today the link between environmental well-being, human well-being, and economic prosperity continues to be part of mainstream political conversation [37].

ii. Ecosystem Services Scope

[29] stated that ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services. As shown in Figure 1, the Millennium Ecosystem Assessment provided a framework for categorizing the societal benefits of ecosystems into four different groupings.

Figure 1: Ecosystem Services. Source: [29]

Provisioning services includes the vast range of food products, biological materials, genes and genetic information used for animal and plant breeding and biotechnology, medicines, food additives animal products such as skins and shells, and also flowers. Fresh water is another example of linkages between categories which is between provisioning and regulating services. Regulating services are closely linked to many fundamental biogeochemical processes, which are the biological and chemical processes that cycle and transform carbon, nutrients (e.g. nitrogen and phosphorus), water, and other materials in the environment [38]. Meanwhile, cultural services are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. Cultural services are closely linked to human values and behavior, as well as to human traditions and outlines of social, economic, and political organization. Therefore perceptions of cultural services are more likely to differ among individuals and communities than, say, perceptions of the importance of provisioning or regulating services such as food production or clean air. On the other hand, supporting services are defined as those services that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, while changes in the other services have more direct and short-term impacts [29].

III. CONCLUSION

GI is a successfully tested tool for providing ecological, economic and social benefits through natural solutions. It helps us to understand the value of the benefits that nature provides to human society and to mobilize investments to sustain and enhance them. It also helps avoid relying on infrastructure that is expensive to build when nature can often provide cheaper, more durable solutions. Many of these create local job opportunities. Green Infrastructure is based on the principle that protecting and enhancing nature and natural processes, and the many benefits human society gets from nature, are consciously integrated into spatial planning and territorial development. Compared to single-purpose, grey infrastructure, GI has many benefits. It is not a constraint on territorial development but promotes natural solutions if they are the best option. It can sometimes offer an alternative, or be complementary, to standard grey solutions.

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