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Implementing Urban Green Infrastructure Solutions for Achieving Sustainable Development Goals

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Abstract

The development and evolution of human society in the actual context are facing new and more demanding challenges. The environment protection issues are becoming more and more important and thus peoples are trying to find new ways to balance the needs for evolution with the care for nature. In this context achieving sustainable development goals is an important objective to all types of social communities. The purpose of this paper is to analyze the sustainable development goals and to identify the role of the green infrastructure in achieving these goals. Green infrastructure is a relatively new concept used, in particular, in cities from Europe and North America to express all the actions that the national or local communities undertake to achieve the sustainable development goals. Another purpose of this paper is to define the green infrastructure concept and popularize it. In this sense among the definition of the concept, we present also the benefits and the challenges of implementing green infrastructure.

Keywords: *green infrastructure, sustainable development, the 2030 Agenda for Sustainable Development, sustainable development goals*

Introduction

Nowadays, more than ever peoples are aware of the importance of protecting nature and the living environment, and thus these are topics of interest for many countries. Cities expand their peripheries to accommodate more and more peoples attracted by the higher urban living standards than rural living standards(Maier and Aschilean, 2020). In a report of the United Nations (UN, 2019) it is showed that more than half of the world's population lives in cities and projections show that the urban population may increase by 60% by 2030. Cities also occupy only 3% of the Earth's land but represent 60– 80% of global energy consumption, 75% of global carbon emissions, and over 60% of resource use. A series of environmental issues arise from this, on a global scale, the most common one is the increased greenhouse gas emissions.

In this context, it is clear that humanity needs to take some measures to continue to respond to the development and evolution request and also to keep the environment safe so humans can live in it. As shown in (Maier, 2019) innovation in the construction industry can bring a lot of benefits to find new ways of developing and evolving but at the same time, the environmental protection issues are becoming more and more important. Within virtually all organizations there is a fundamental tension between the need for stability and the need for creativity(Maier, Olaru and Maier, 2013; Maier, 2018b). On the one hand, companies require stability and static routines to accomplish daily tasks efficiently and quickly. This enables organizations to compete today. On the other hand, companies also need to develop new ideas and new products to be competitive in the future, hence they need to nurture a creative environment where ideas can be tested and developed.

As a response to all of these new challenges in 2015, the United Nations launched the *2030 Agenda for Sustainable Development* (United Nations, 2015) with the purpose *to end poverty and set the world on a path of peace, prosperity, and opportunity for all on a healthy planet*. The lunched Agenda is based on a set of 17 goals that humanity is trying to achieve. These 17 goals as stated in the 2015 release Agenda are:

- ☑ *Goal 1*. End poverty in all its forms everywhere
- ☑ *Goal 2*. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
- ☑ *Goal 3*. Ensure healthy lives and promote well-being for all at all ages
- ☑ *Goal 4*. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- ☑ *Goal 5*. Achieve gender equality and empower all women and girls
- ☑ *Goal 6*. Ensure availability and sustainable management of water and sanitation for all
- ☑ *Goal 7*. Ensure access to affordable, reliable, sustainable, and modern energy for all
- ☑ *Goal 8*. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- ☑ *Goal 9*. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- ☑ *Goal 10*. Reduce inequality within and among countries
- ☑ *Goal 11*. Make cities and human settlements inclusive, safe, resilient and sustainable
- ☑ *Goal 12*. Ensure sustainable consumption and production patterns
- ☑ *Goal 13*. Take urgent action to combat climate change and its impacts
- ☑ *Goal 14*. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- ☑ *Goal 15*. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- ☑ *Goal 16*. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- ☑ *Goal 17*. Strengthen the means of implementation and revitalize the global partnership for sustainable development

As it can be seen in the last years the concept of sustainable development has gained recognition and consistency, along with the emergence and development of international standards for management systems(Maier, 2018c), today viewed as a socio-economic model able to bear the global economy over the challenges and traumas of the economic crisis triggered in 2008 (Maier, 2018a).

From the initial development of the 2030 Agenda in the last year, since 2020, the entire modern world is facing a huge challenge given by the effects of the COVID 19 pandemic. In this sense, the last report on implementing the 2030 Agenda for Sustainable Development (United Nations, 2020) shows that before the COVID-19 pandemic, progress remained uneven and we were not on track to meet the Goals by 2030 and that change was still not happening at the speed or scale required. In the current moment, due to COVID-19, unprecedented health, economic and social crisis is threatening lives and livelihoods, making the achievement of Goals even more challenging.

At the end of the foreword of the Sustainable Development Goals Report 2020 (United Nations, 2020), the Secretary-General of the United Nations António Guterres is saying that "*at the start of this Decade of Action to deliver the SDGs, I call for renewed ambition, mobilization, leadership and collective action, not just to beat COVID-19 but to recover better, together – winning the race against climate change, decisively tackling poverty and inequality, truly empowering all women and girls and creating more inclusive and equitable societies everywhere*".

In all of this context, the approach of this paper is to examine if the green infrastructure can be a solution to achieve some of the sustainable development goals and can contribute to speeding up the implementation of these goals. In this sense, we address this topic first by identify the definition of the green infrastructure concept and highlighting the main benefits. Then we studied the green infrastructure concept in the context of the evolution of the main competitive economic factors and we compare it with the approach of the subject in the literature. We present also all the benefits and challenges of implementing the green infrastructure. At the end of the paper, we open the conclusion and discussion part with the main connection and contribution of the green infrastructure concept to the sustainable development goals.

2. Green infrastructure concept

Green infrastructure is a concept more and more used, especially in Europe and North America, to express all the policies that the national and local communities are taking to achieve sustainable development goals. In Europe, the European Commission adopted an EU strategy on green infrastructure (GI strategy) in 2013 (European Commision, 2013) to enhance economic benefits by attracting greater investment in Europe's natural capital to achieve its biodiversity objectives by 2020. It included four priority work streams: *promoting GI in the main policy areas*; *improving information*, *strengthening the knowledge base* and *promoting innovation*; *improving access to finance*; and *contributing to the development of GI projects at the EU level*.

According to the European Union report (European Commision, 2018) green infrastructure is defined as *a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. More specifically green infrastructure, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water*.

In United State, the Environmental Protection Agency (US EPA, 2012) is referring to the green infrastructure *as it mimics the natural processes to improve water quality and manage water quantity by partly restoring the hydrologic function of the urban landscape*. In Germany, the green infrastructure, in the work of (Mayer and Schiller, 2017) is seen as: "*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, green infrastructure is present in rural and urban settings*."

The researchers (Liberalesso *et al.*, 2020) show that worldwide, green infrastructure is increasingly used to mitigate the impacts of dense urban areas, contributing towards the naturalization of the built environment. In the same paper, they also state that also implementation of the green infrastructure can bring a lot of benefits for investors, these systems often emerge as requiring substantial upfront cost (high installation costs) and, depending on the solution, might also have significant maintenance costs(Maier *et al.*, 2014). On the other hand, policymakers are placing green infrastructure on the agenda, as a solution to consider in urban planning and design. So in these conditions, there is a mismatch between the economic/social/ environmental value of green infrastructure and their financial analysis.

Among the main benefits stated in the EU report (European Commision, 2018) are grouped on several aspects. The first set of benefits are felted on the environmental level, this benefits can be:

- Provision of clean water
- Removal of pollutants from air and water
- Pollination enhancement
- Protection against soil erosion
- Rainwater retention
- Increased pest control
- Improvement of land quality
- Mitigation of land take and soil sealing

The second set of benefits are related to the social benefits, among these are:

- Better health and human well-being
- Creation of jobs
- Diversification of the local economy
- More attractive, greener cities
- Higher property values and local distinctiveness
- More integrated transport and energy solutions
- Enhanced tourism and recreation opportunities

The third level of advantages of implementing green infrastructure can be related to climate change adaptation and mitigation benefits, such as:

- Flood alleviation
- Strengthening ecosystems resilience
- Carbon storage and sequestration
- Mitigation of urban heat island effects
- Disaster prevention (e.g. storms, forest fires, landslides)

The last category of benefits specified in the report are the biodiversity benefits:

- Improved habitats for wildlife
- Ecological corridors
- Landscape permeability

In the 2019 report, analyzing the results of implementing the green infrastructure strategy at the European level (European Commision, 2019) it is specified that in the EU, green infrastructure (GI) includes the Natura 2000 network as its backbone, as well as natural and semi-natural spaces outside Natura 2000, such as parks, private gardens, hedges, vegetated buffer strips along rivers or structure-rich agricultural landscapes with certain features and practices, and artificial features such as green roofs, green walls, or ecobridges and fish ladders. The annual benefits of ecosystem services provided by the Natura 2000 network alone have been estimated at EUR 300 billion across the EU, with the benefits of GI going well beyond.

Green infrastructure includes, among other solutions, the integration of vegetated surfaces in buildings, as in rooftops (green roofs) or building walls (green walls). Green roofs and green walls systems have great potential to mitigate the impacts of dense urban areas, bringing benefits at social, economic, and environmental levels (Liberalesso *et al.*, 2020; Teotónio *et al.*, 2020)

3. Challenges of green infrastructure in today's context

As the cities became too suffocating and crowded, humans began to feel the need to return to nature, and one of the simplest means is to bring the plants inside. The development of human society at an increasingly fast pace, especially in recent years, has led to an awareness of the effect of human activity on the environment. The importance given to environmental protection issues can also be seen in the light of the evolution of the key forces for determining competitiveness in the economic sector (Figure 1).

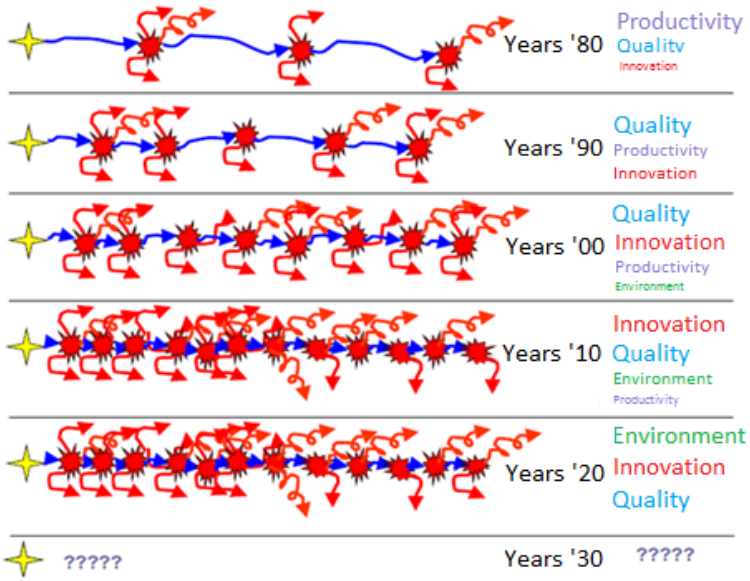

Figure 1. The evolution of the importance of the environment from the perspective of the key forces for determining competitiveness in the economic sector

It can be seen that in the ‘80s, the emphasis was on productivity, quality being on the second position, innovation is found only in some points and environmental issues were unimportant. In the 1990s, competition in global markets led organizations to consider quality as a key driving force, without omitting productivity from the competitiveness equation, the innovation part and the environment were not taken into account. In the 2000s there was a change of priorities and organizations realized that innovation is as important as quality to ensure a competitive advantage in the market. The focus on productivity is declining and we can see that there are concerns about environmental protection in the equation of competitiveness.

In 2010, the key factors in determining competitiveness are considered: innovation, quality and the environment and productivity is starting to decline significantly in importance. Today, in the last decade to 2020, we can see that the pressing challenges posed by climate change have led to the consideration of the environment as the most important factor alongside innovation and quality.

This increase in the importance given to the development of systems for environmental protection can also be seen in the field of research. In this sense, we perform a search in the ISI Web of Science database using “green infrastructure” as a keyword and we extract the total number of articles published and indexed in the database. The evolution of the number of articles can be seen in figure 2.

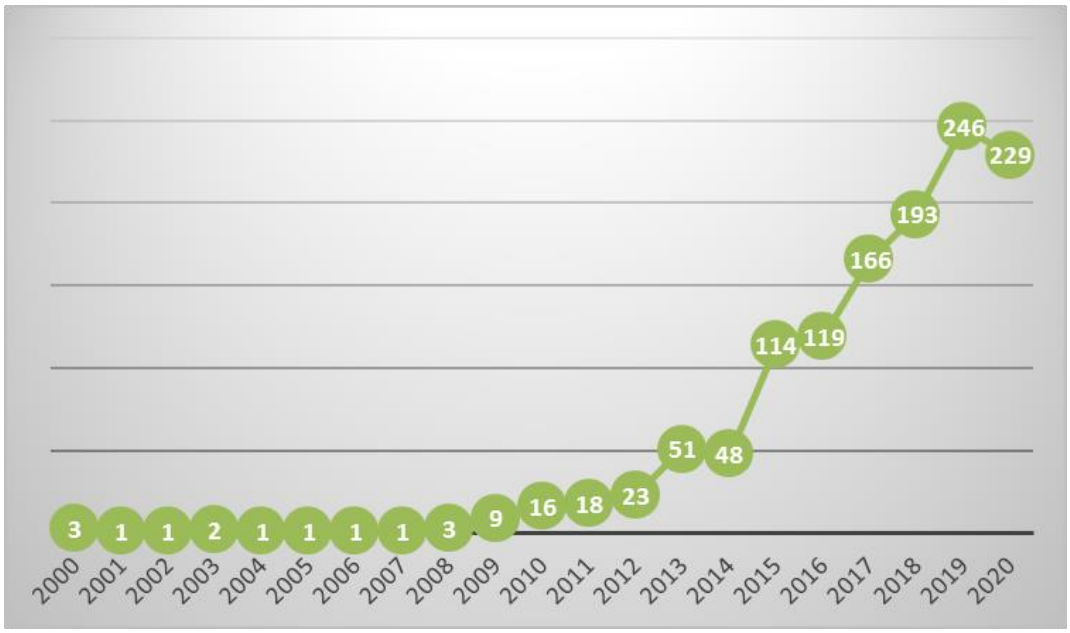

Figure 2. Evolution of the number of published articles indexed ISI WoS having the topic green infrastructure

From the above graph, it can be observed and confirmed the lack of importance of environmental issues before the year 2000, following the query of the database no article was published on this topic. Environmental issues appear easily in the 2000s and then this issue becomes more and more important starting with 2009 but especially 2010. We can see an upward trend in the number of articles with a substantial increase in 2019 when they were published with almost 250 articles more than in 2010. It can be seen that this upward trend continues today and there are premises for the importance of environmental protection to increase in the coming years. As a particularity, we performed this interrogation at the beginning of March 2021 and we did not include in the graphs the articles published in 2021. As an absolute value in March 2021 were already published 51 papers so this is highlighting again that the concerns regarding environmental protection are increasing.

In this context, we can observe that green infrastructure is seen as a solution to achieving sustainable development goals. Although several communities experience the benefits from implementing green infrastructure the concept is still new and it still has a lot of challenges to overcome. Several researchers address this subject identified and provided solutions to overcome the main challenges for implementing green infrastructure. The purpose of this paper is not to perform a literature review of the literature so we will only highlight the most common challenges identified without claiming that these are all the barriers in implementing green infrastructure.

In the research of (Zuniga-Teran *et al.*, 2020) they correlate the challenges in five main categories as design standards, regulatory pathways, socio-economic trends, financial ability, and innovation. In the case of the first category, the design standards, the researchers *argue for the need for a standardized design process for hybrid infrastructure that aligns with the regulatory framework and includes a maintenance commitment.* The researchers explain this argument because they consider that the green infrastructure design *must consider the multi-functionality aspect that includes social uses (recreation) and ecological uses (habitat and landscape connectivity).* In order to have success with these challenges, in the same paper, the authors highlighted that "f*or a successful design, the input of users and specialists must be considered".*

The second category of challenges identified by Zuniga-Teran et al (Zuniga-Teran *et al.*, 2020) is related to the regulatory pathways. Here the researchers highlighted the need to develop a regulatory body that *can capture the green infrastructure multidimensional benefits* and they propose to achieve this by *creating a new spatially defined regulatory body that overrides other branches of the complex regulatory apparatus*. For the third category of the challenges, the socio-economic trends, the researchers *see equity issues involved around green infrastructure, where low-income communities are disproportionately affected.* In case of the fourth category of challenges, the financial ability, they state that *the cost of no action makes a convincing argument for investing in green infrastructure and other resilience initiatives* although they also highlight that *it is unclear who pays for this investment, who maintains green infrastructure, and how to quantify all green infrastructure benefits.* In the last category of challenges, the researchers included innovation, here they point out that green infrastructure can create more opportunities for innovation and by *stakeholder engagement and close collaboration between different groups* it can result in the *wide implementation of green infrastructure with public support and agreed on maintenance commitment.*

The changes of the green infrastructure implementation were also studied on the institutional level such as the United State Environmental Protection Agency published a set of barriers and solutions to overcome them (US EPA, 2020). Here the barriers are grouped into three main categories, the first category is reserved for the barriers Confronting Municipalities, the second category are the barriers Confronting Developers and the third category are the Design Challenges. The main barriers that local authorities have when dealing with greed infrastructure are:

- The perception that performance is unknown.
- The perception of higher costs.
- The perception of resistance within the regulatory community.
- The perception of conflict with principles of smart growth.
- The perception of conflict with water rights law.
- The unfamiliarity with maintenance requirements and costs.
- Conflicting codes and ordinances.
- The lack of Government staff capacity and resources.

In the case of Developers, the EPA identified that the main barriers in dealing with green infrastructure are related to Skepticism about Long-Term Performance and Perception of Higher Costs. In the last category, EPA identifies the same problems as the researchers Zunica-Teran et al., with the design challenges. In this case, EPA formulates that *municipalities, developers, and engineers often express skepticism that green infrastructure is appropriate for their particular context.*

Conclusions

The current socio-economic context is facing new and more demanding challenges. Modern societies are facing, now more than ever, an increase of dynamic changes that are stretching the limits and force us to find new ways to continue the development and evolution and at the same time to find ways to take care of nature. If we analyze the evolution of the economic competitive factors we can observe how society evolves and how people react to the new challenges. If in the ’80s there was a race to productivity, people just wanted to have a lot of things, the society evolves and they observe that it is not worth to have something if you cannot use it for a long period of time, so in the ’90s quality gained more importance. The next step in the evolution was that people wanted something of quality but also something new and in the 2000s innovation appears as an important characteristic. Then the society continues to evolve and in the next decade, in the 2010s innovation was the most important characteristic together with quality. At the same time, humanity became more and more aware that natural resources are limited and the environment needs protection, we saw that if we continue to do the same things in the future maybe we will not have a planet where to stay. All of this process of reconsidering our values and our way of dealing with the environment was and is still increased by the COVID -19 pandemic where we could see that something that seems endless can quickly disappear.

In this context, the implementation of solutions to reduce the impact of human activity on the environment must be accelerated and find ways to implement them. The 2030 Agenda for Sustainable Development launched in 2015 by the United Nations tries to give a direction and some goals that if we will achieve them we will be able to change and create new societies that will offer better use of the resources for the common welfare. Green infrastructure is a category of solutions that can bring a lot of benefits both to the environment and also to the societies and can help to achieve sustainable development goals.

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