Chapter

Green Stormwater Infrastructure in the Context of the European Green Deal Policy

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Abstract

It is thought that this section will make an important contribution to the literature and at least reflect the strong link between green stormwater infrastructure and the European Green Deal Policy to the readers. The European Green Deal has targets covering many different sectors, including construction, biodiversity, energy, transportation, and food, which include the enactment of new laws on green rainwater infrastructure. Green stormwater infrastructure not only controls stormwater volume and timing but also supports the benefits ecosystems bring to us. Stormwater is defined as rainwater or melted snow runoff from streets, lawns, and other areas. When rainstorm water is absorbed into the soil, it is filtered and eventually replenishes aquifers or flows into streams and rivers. Runoff carries sediments, nutrients, or other pollutants into water sources that degrade water quality, threaten drinking water supplies, and complicate water treatment processes. When drought concentrates pollutants, it can further limit dilution, making worse conditions. In order to prevent the problems caused by inefficient rainwater management systems, green infrastructure applications that mimic natural habitats, absorb excess water, and help protect water while preserving water quality have gained importance in recent years.

Keywords: the European Green Deal, green infrastructure, stormwater management, rainwater, sustainability

1. Introduction

The European Green Deal aims to make the European Union climate neutral by 2050 and reduce greenhouse gas emissions by at least 50% and 55% compared to 1990 levels, transforming the EU into a resource-efficient competitive economy and leaving no one and nowhere behind signed for. This agreement will require a review of every single law on climate, circular economy, building renovation, biodiversity, farming, and innovation. It also has targets covering many different sectors, including construction, biodiversity, energy, transportation, and food. **Figure 1** shows the various elements of the European Green Deal.

The most striking result of this strategy is that it includes potential carbon tariffs for countries that do not reduce their greenhouse gas emissions at the same rate.

Figure 1.
The various elements of the European Green Deal [1].

The mechanism to achieve this is called the Carbon Limit Adjustment Mechanism (CBAM). Other mechanisms of this strategy are circular economy action plan, Emissions Trading System (ETS), Farm to Fork strategy, possible revision of all climate-related policy instruments, sustainable and smart mobility strategy, and forest protection and restoration. As the first step, Member States must update their climate and national energy plans in 2023 to match the EU's 2030 climate target.

The European Commission has announced the EU Energy System Integration Strategy for cleaner and greener energy. This strategy includes measures to develop clean fuels (including hydrogen) to develop a circular system.

Another strategy to achieve the EU's climate targets is the Circular Economy Industrial Policy. The EU has announced this strategy in order to revitalize industrial zones and have the best technologies. Circular economy-friendly commodity markets are a strategy that requires the decarbonization and modernization of energy-intensive industries such as steel and cement. The "sustainable products" policy, which focuses on reducing waste of materials (textile, construction, vehicle, battery, electronics, and plastic) and aims to reuse products and strengthen recycling processes, is also envisaged.

The building and renovation policy focuses on promoting the use of energy-efficient building methods, increasing digitalization, and tripling the renovation rate of all buildings.

The Commission's Zero Pollution Action Plan aims to ensure that no pollution comes from all industrial activities by 2050. This strategy also includes the substitution of toxic substances used in industries with toxic ones.

Reducing emissions from transport methods is another target area under the European Green Deal. It includes the implementation of a comprehensive strategy on "Sustainable and Smart Mobility" that will increase the use of sustainable and alternative fuels in land, sea, and air transport, set emission standards for internal combustion engine vehicles, and offer a sustainable alternative. As a solution, the development of smart traffic management systems and applications, smart load distribution management, and the creation of charging points for electric vehicles are among the objectives of this strategy.

Sustainable finance, or green finance, is supported by the adoption of the Paris Climate Agreement, which requires parties to build financial flows consistent with low greenhouse gas emissions and a pathway to climate-resilient development.

The Farm to Fork' strategy is a strategy that includes the support given to farmers and fishermen as well as the production and transfer methods of these resources, in addition to the issue of food sustainability, and adopts a climate-friendly approach. Specific target areas include reducing chemical pesticide use, increasing the availability of healthy food options, and helping consumers understand the health ratings of products and sustainable packaging. The Farm to Fork strategy is geared toward a better balance of nature, food systems, and biodiversity and includes the following objectives: [2].

- To organicize 25% of EU agriculture by 2030.
- To reduce pesticide use by 50% by 2030.
- To reduce the use of fertilizers by 20% by 2030.
- To reduce nutrient loss by at least 50%.
- To reduce the use of antimicrobials in agriculture and antimicrobials in aquaculture by 50% by 2030.
- To establish sustainable food labeling.
- To reduce food waste by 50% by 2030.

The biodiversity strategy is an important part of the EU's climate change mitigation strategy and includes the allocation of 25% of the European budget to combating climate change in order to restore biodiversity. The EU Biodiversity Strategy for 2030 includes the following objectives: [2].

- Conservation of 30% of sea lands and 30% of land lands, especially primary forests and old forests.
- Planting 3 billion trees by 2030.
- Restoring at least 25,000 kilometers of rivers for free flowing.
- 50% reduction in pesticide use by 2030.
- Increasing organic agriculture.
- Increasing biodiversity in agriculture.
- Reversing the decline of pollinators.

The development of green infrastructure is an important step toward the success of the EU 2020 Biodiversity Strategy, with the strategy's second objective requiring "by 2020, the maintenance and development of ecosystems and their services by establishing green infrastructure and restoring at least 15% of degraded ecosystems." However, green infrastructure contributes to the full implementation of all six objectives of the strategy – specifically the Birds and Habitats Directive (target 1) and to the conservation and enhancement of biodiversity in the wider rural and marine environment (targets 3 and 4) [3].

The Commission has adopted an EU-wide strategy that encourages investment in green infrastructure to restore the health of ecosystems, keep natural areas connected, allow species to thrive in their natural habitat, and promote green infrastructure across Europe. It is designed to provide ecosystem services such as green infrastructure planning, water purification, air quality, recreation space, and climate mitigation, providing environmental, economic, and social benefits through natural and seminatural solutions. This network of green (land) and blue (water) areas improves environmental conditions, thereby increasing the health and quality of life of citizens, creating job opportunities, increasing biodiversity, and supporting the green economy [4].

2. Green stormwater infrastructure

As it is known, the storm or flow moves over the ground by gravity and reaches streams, rivers, ponds, lakes, and oceans. With urbanization, impermeable surfaces (roofs, streets, parking lots, and sidewalks) increase, so the permeable areas decrease and as a result, the volume of storm water flow increases. Stormwater management strategies include the prevention, containment, and reuse of stormwater runoff.

Green stormwater infrastructure is systems like biological ditches, catchments, wetlands, rain gardens, and urban green spaces that mimic natural processes that result in infiltration, evaporation, or use of rainwater. It is becoming increasingly clear that green stormwater infrastructure not only controls stormwater volume and timing but also supports ecosystem services, which are the benefits ecosystems provide to humans.

"Green Infrastructure can be broadly defined as a strategically planned network of high-quality natural and seminatural 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 GI, 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" [5].

"Green infrastructure is a strategically planned network of natural and seminatural 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" [6].

" Green infrastructure is an approach to wet weather management that uses soils and vegetation to utilize, enhance, and/or mimic the natural hydrological cycle processes of infiltration, evapotranspiration, and reuse" [7].

Traditional stormwater infrastructure, or gray infrastructure, is designed to divert rainwater from urban areas through pipes and channels. Runoff from these

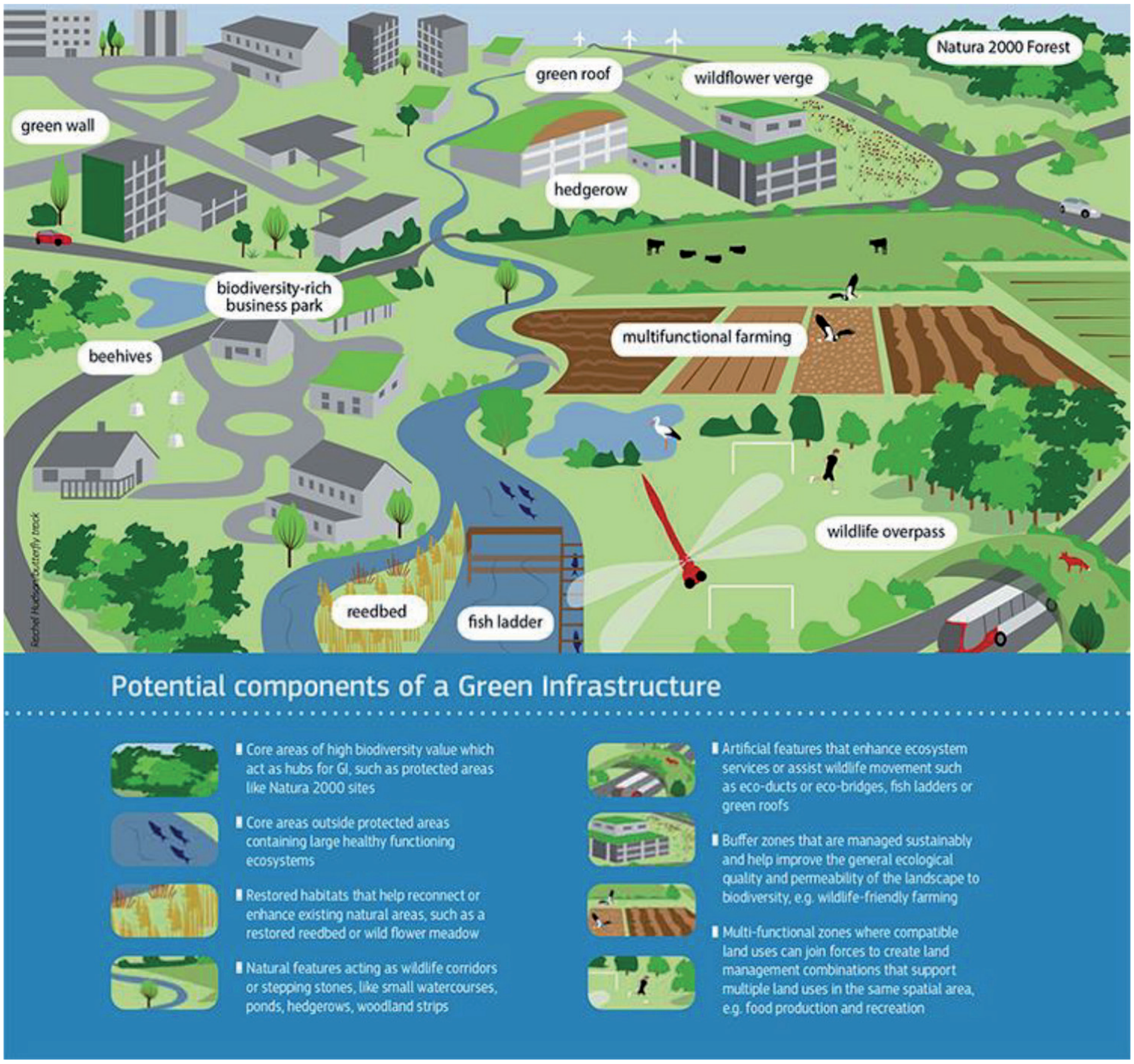

Figure 2.
Potential components of a green infrastructure [9].

surfaces can suffocate infrastructure systems, carrying pollutants into streams, rivers, and lakes when rainwater runs off impermeable streets, parking lots, sidewalks, and roofs. Flows can also cause erosion and flooding that can damage property, infrastructure, and wildlife habitat. In addition to flow problems, impermeable surfaces also prevent water from penetrating the soil and refilling groundwater sources.

Green infrastructure uses plants, soils, landscape design, and engineering techniques to contain, absorb, and reduce polluted stormwater runoff. Green infrastructure prevents combined sewer overflows for cities by preventing or reducing the amount of runoff flowing directly into storm drains. It provides many environmental, social, and economic benefits such as improved surface water quality, water savings, and improved esthetics.

Improved water quality, increased water supply, reduced flooding, improved air quality, greater resilience to climate change, and increased habitat improvement are examples of environmental benefits of GI. The economic benefits are increased property values and reduced filtering costs and infrastructure cost savings. Choosing green infrastructure over traditional gray infrastructure such as concrete pipes has the following advantages [8]:

- It is more attractive, effective, and multifunctional.
- Provides habitat for beneficial wildlife.
- It can eliminate mosquito breeding habitat.
- Infrastructure costs are reduced compared to gray infrastructure.
- Eliminates stagnant water that could serve as a mosquito breeding habitat.

Restoring floodplain forest instead of building a dam not only benefits the local community but also forests with a good mix of species and ages can absorb large amounts of water, protecting the soil and preventing or at least reducing the effects of floods and landslides. It also provides habitats for animals, offers recreation areas, and contributes to reducing global climate change through carbon sequestration. Properly designed parks, city gardens, green roofs, and walls all contribute to biodiversity. In addition, it helps combat climate change, significantly improves the health and well-being of urban residents, and improves social cohesion and the quality of the living environment. **Figure 2** represents potential components of green infrastructure.

3. Green stormwater infrastructure techniques

Green infrastructure techniques use soils and vegetation to infiltrate, evaporate, and/or recycle stormwater runoff and techniques for sustainable rainwater management are as follows [10]:

- Green roofs or eco-roofs.
- Downspout disconnection.
- Rainwater harvesting and reuse systems (water retention tanks).
- Natural stormwater drainage systems (bioswales and vegetative swales).
- Stormwater planters, curb extensions, and infiltration gardens.
- Stormwater basins (detention and retention basins, and ponds).
- Efficient landscaping and irrigation.
- Reduce the area of impervious surfaces and use of pervious paving (pervious asphalt, concrete and structural grass-paving systems).
- Stream rehabilitation and daylighting projects.

3.1 Urban forests

Urban forests, as the name suggests, are an important component of urban green infrastructure systems in cities. These forests are esthetically valuable forests that reduce the need for maintenance and irrigation and use suitable tree and plant species instead of harmful and invasive species.

The benefits of urban forests [1] are as follows:

- Energy savings: It has been found that trees planted around houses can save up to 47% of energy for heating and cooling.

- Urban heat island: Thanks to the evaporative cooling mechanism, wooded areas have been found to have lower air temperatures than open areas without trees. Urban heat islands negatively affect human health by causing heat to intensify due to the materials and infrastructure used.

- Water management: It has been found to help city water management by diverting large amounts of precipitation hitting trees through water channels through urban forests.

- Air pollution: Trees act as carbon sinks, improving air quality in cities.

- Property values: It has been found that the value of the property increases as the amount of trees above its value increases.

- Public health: It shows that urban greenery can positively improve people's mental and mental health.

3.2 Constructed wetlands

Wetlands are often built on floodplains, and with proper planning and management, they help prevent changes in natural hydrology and the introduction of invasive species. By using the natural processes of plants, soils, and microorganisms, it can hold a large part of suspended solids, slow down the water flow, and provide the purification of pollutants.

The benefits of constructed wetlands are as follows [1]:

- Water efficiency: Constructed wetlands attempt to mimic natural wetland ecosystems. They were built to improve water efficiency and water quality.

- Cost-effective: Wetlands have low operating and maintenance costs.

- Esthetics: Built wetlands can add greenery to their surroundings.

3.3 Green and blue roofs

Green roofs improve air and water quality while reducing energy costs. Plants and soil provide more green space and insulation on roofs. Green and blue roofs help reduce urban runoff by trapping precipitation in stormwater management in dense urban areas. Green roofs also act as a carbon sink, trapping carbon pollution. It has been found that 40–80% of the total rain volume falling on green roofs can be reserved. Since the water released from the roofs will flow at a slow rate, they cause a decrease in the amount of runoff entering the basin at once. Although blue roofs do not technically count as green infrastructure, they function to collect and store precipitation, reducing the flow of water flowing into sewer systems. Blue roofs also help to save energy by reducing cooling costs.

Other benefits are as follows [11]:

- Reducing ambient air temperatures by shading the roof in summer.
- Prevention of heat transfer in winter.
- Absorption, retention, filtering, and storage of precipitation.
- Minimizing the effects of impermeable surfaces.
- Extending the life of roofing membranes.
- Increasing green space and wildlife habitat.
- Developing city esthetics.
- Improving air quality by acting as a carbon sink.
- Reducing runoff and benefiting the capacity of urban stormwater infrastructure.

Some advantages of green roofs over reflective roofs [11] are as follows:

- They use radiant energy to cool the ambient air instead of reflecting sunlight onto adjacent buildings.
- They can resist UV radiation.
- They can ensure a long life by protecting the roof membrane.
- They increase the esthetic value by providing green space.

Some disadvantages of green roofs over reflective roofs [11] are as follows:

- Higher initial costs due to additional material and higher installation costs.
- Some ongoing maintenance is also required, such as fertilizing the vegetation annually and checking the plants until the plants are fully established and the roof is fully covered.
- Since they are not mechanically fixed to the roof, they are sensitive to strong winds.
- Any leak in the waterproofing material is difficult to find.
- They do not work well on very steeply pitched roofs.

3.4 Rain gardens

Rain gardens are areas with shrubs and plants that collect rainwater from roofs or sidewalks, allowing the rainwater to seep slowly into the ground. It is an alternative to reduce urban water flow and slow the flow of water by infiltration. In residential applications, water flow can be reduced by 30% by using rain gardens in the garden of the house.

3.5 Downspout disconnection

Downspout disconnection is a form of green infrastructure that separates roof downspouts from the sewer system and directs roof water flow to permeable surfaces, used to store rainwater or allow water to penetrate the ground. It is clear that disconnecting the downspout would be particularly beneficial in cities with combined sewer systems.

3.6 Bioswales

Bioswales, much like rain gardens, can be depicted as channels with vegetation or much often placed in long narrow spaces in urban areas. They absorb runoff or carry stormwater runoff from heavy rains into sewers or directly into surface waters. Vegetative bioswales infiltrate, slow, and filter stormwater streams that are most beneficial along streets and parking lots.

3.7 Green alleys

It can be characterized as redesigning existing passages to reflect more light to reduce the heat island effect, capture rainwater, and make the space usable. In addition to its ecological benefits, green alleys provide open spaces by transforming previously unsafe areas into playgrounds and walking/bike corridors.

4. Conclusion

Combined sewer systems that include sewage and stormwater streams are unfortunately common in many older municipalities. Urban sustainability, on the other hand, is the management of stormwater runoff, which has become an increasingly challenging issue with the increasing amount of impermeable space in urban environments. Increasing political, social, and environmental pressures are forcing engineers to reduce the number and severity of floods or combined sewer overflows.

Summing up the benefits of green infrastructure for people living in cities, it causes a drastic increase in biodiversity that supports rich wildlife communities, including many rare and endangered species [12, 13], its significant impact on climate mitigation due to the reduction of urban heat islands [14, 15], its positive effects on the control of runoff [16, 17], and removing air-borne pollutants [18].

EU strategy on green infrastructure refers to the goal of "no net loss of biodiversity and ecosystem services by 2020." This approach should include no net loss of green infrastructure. This policy incorporating the concepts of water, biodiversity, soil, climate, air, and landscape thus allowing green infrastructure is to be addressed in a holistic issue.

This chapter intends to provide the reader with a comprehensive overview of urban and rural area stormwater management, green infrastructure practices, green stormwater solutions, benefits of green stormwater infrastructures, and climate adaptation to stormwater runoff.

The author advocates the concept of green infrastructure, claiming to offer a progressive planning approach that facilitates synergies between economic growth, environmental protection, and social development.

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