2 Green infrastructure: Conceptual framework and international context

This chapter sets out the scene for the analysis and assessment conducted in the subsequent sections of the report. Building on an in-depth literature review and interviews with stakeholders at the national and sub-national level, it outlines the conceptual framework underpinning green infrastructure (GI) and nature-based solutions (NbS) in Italy. The chapter brings forth the main definitions and highlights the key features and associated benefits and co-benefits of these two instruments (e.g. climate change mitigation and adaptation, leisure, job opportunities, health and well-being, etc.). It also provides an overview of the most relevant international and European strategies and includes a short analysis of the use of GI and NbS in the transport sector and in urban regeneration.

2.1. What is green infrastructure (GI)?

GI does not have a single uncontested definition[1]. In 2013, In the **European Commission** released the **EU Strategy on Green Infrastructure** and defined **GI 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, GI is present in rural and urban settings*" (European Commission, 2013[1]). GI interventions can range from the protection or restoration of existing habitats (e.g. mangrove forests, coral reefs, etc.) to the creation or enhancement of entire ecosystems (e.g. developing new forests or other green areas) (OECD, 2021[2]). **Their main objective is to strengthen the ecological connectivity across green areas, as well as to protect, restore and enhance biodiversity and ecosystem services** (i.e. the goods and services the nature provides and upon which humans, as well as any other species, are dependent). Unlike single-purpose, grey infrastructure[2], GI performs a number of useful functions simultaneously and at very low comparative cost, creating benefits for people, nature and the economy.

The 2013 EU Strategy aims at making GI a standard component in spatial planning and territorial development and promotes the integration of GI in national and sub-national policies. Most notably, the Natura 2000 network (see Box 2.1) represents the backbone of GI implementation in the EU (European Commission, 2013[1]).

Box 2.1. The Natura 2000 network

Natura 2000 is an EU-wide network of protected areas spanning across all the 27 EU Member States. It includes over 27 thousand sites, covering approximately 18% of EU land territory and 6% of EU marine areas. Overall, the network contributes to the protection and conservation of nearly 1,400 species between animals and plants and 233 different types of habitats. The Natura 2000 network includes both the Special Areas of Conservation (SACs), which are identified by the EU Member States according to the EU Habitats Directive (1992), and the Special Protection Areas (SPAs), which are envisaged by the EU Birds Directive (released in 1979 and updated in 2009). The network offers an important reservoir and protection mechanism for biodiversity, and it also ensures the delivery and maintenance of many ecosystem services, the value of which has been estimated at EUR 200-300 billion per year.

In Italy, the Natura 2000 network covers 19% of the national land territory and almost 4% of Italy's territorial seas. It extends across four bio-geographical regions – i.e. Alpine, continental, Mediterranean, and marine-Mediterranean – for a total of 2 613 sites. The network supports the protection and conservation of more than 3 thousand species of birds and other 235 animal species (including insects, reptiles, amphibians, mammals, molluscs, and fish), as well as 115 species of plants and 132 types of habitats

Source: (The Council of the European Union, 1992[3]; European Commission, 2014[4]; European Commission, n.d.[5]; LIFE Sic2Sic, n.d.[6])

Likewise, the European Commission defines **Natural Based Solutions (NbS)** as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" (European Commission, 2021[7]). Overall, NbS consist in human interventions that build on nature and mimic its underlying processes to address societal challenges, such as improving air or water quality and strengthening resilience to extreme climate events (OECD, 2021[2]). Most importantly, they help support GI's objectives at the project-level. NbS can also be integrated with grey infrastructure to reduce their environmental impact, enhance their effectiveness and lifespan, and increase climate resilience, as well as to support ecological connectivity and restore ecosystem services. For example, the use of green walls and green roofs in building design helps reducing energy needs, contributes to mitigate damages from extreme heat and heavy rains and support ecosystem services (OECD, 2021[2]).

With the objective to gain a better understanding of how GI and NbS are currently implemented in Italy, the EU, and worldwide, **the OECD has collected and analysed countries' experiences**. To date, it has gathered 32 examples from Italy and 45 examples from other countries across the globe. In order to have a comprehensive and diversified compendium of practices, the OECD has classified the examples according to six different criteria:

1. Location (country)
2. Levels of government involved (local or municipal, regional, state and country level)
3. Scale and type (small vs. large scale projects, green roofs, urban parks, re-naturalisation of rivers, peri-urban forests, etc.)
4. Source of financing (public, private, national, international, EU, etc.)
5. Sector (transport, building, water management, etc.)
6. Status of implementation (design phase, construction, maintenance, etc.)
7. The most relevant examples have been included in chapter 3 and 4 of the report to illustrate good practices and inform ways forward.

2.2. Green infrastructure supports ecosystem services

GI has a multifunctional nature. If well-planned, it can deliver multiple functions and services simultaneously, therefore satisfying different needs, achieving different objectives, and providing different benefits at the same time (OECD, 2021[8]; Henriette, Neubert and Marrs, 2019[9]). As mentioned above, one of the key characteristics of GI is its capacity to protect, sustainably manage, restore, or enhance ecosystems and their services. Ecosystem services are the goods and services that nature provides and upon which humans, as well as any other species, are dependent. They can be grouped into four categories: (i) provisioning services, (ii) regulatory and maintenance services, (iii) cultural services, and (iv) supporting services (Henriette, Neubert and Marrs, 2019[9]).

Provisioning services are those ecosystem services that provide humans with direct physical goods, such as food, drinking water, material and energy resources (e.g. fibres from plants, timber, natural gas, oils, wood and crop fuels, medicinal products, etc.) (Henriette, Neubert and Marrs, 2019[9]).

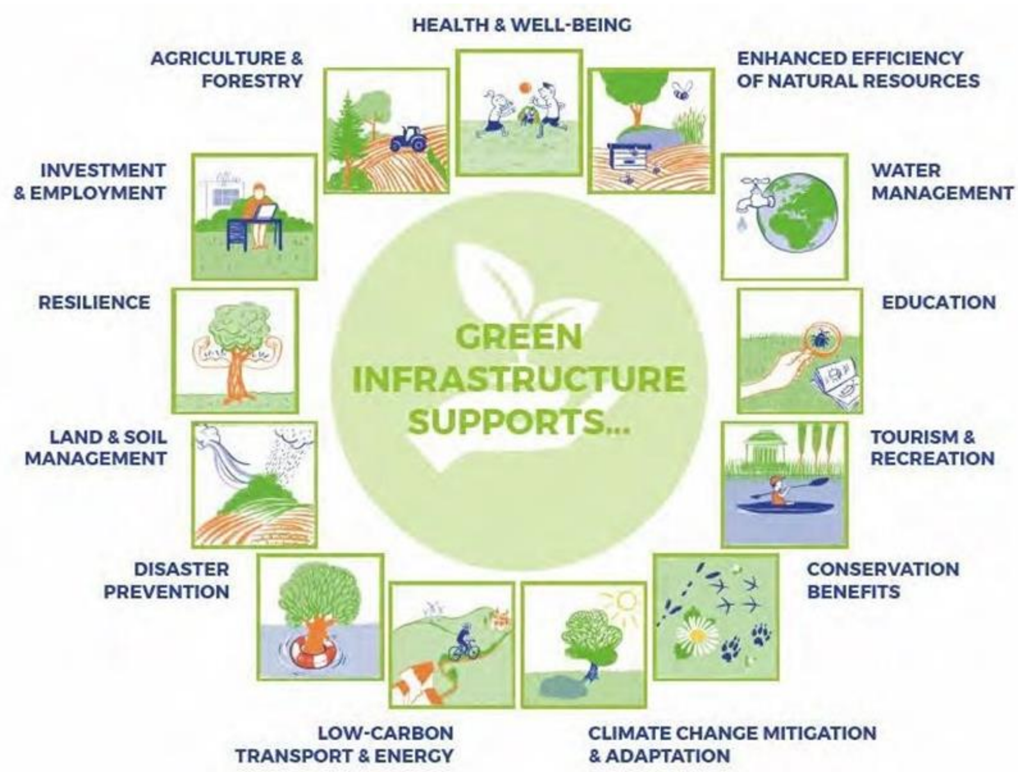
Regulatory and maintenance services provide benefits to humans from the regulation of ecosystem processes, contributing to keep ecosystems functional, sustainable, and resilient to change. They include water and air filtering (e.g. through vegetation and soils that absorb pollutants), land erosion and flood control (e.g. through vegetation), reduction of waste flows (e.g. through bacterial activity), pollination, climate regulation (e.g. regulation of temperatures and humidity through vegetation and water basins), carbon capture and storage, protective functions (e.g. coastal protection through coral reefs, sand dunes or shelter belts), and maintenance of physical, chemical and biological conditions (Millennium Ecosystem Assessment (MEA), 2005[10]; Henriette, Neubert and Marrs, 2019[9]).

Cultural services include the non-material benefits that contribute to cultural development and practices, e.g. through recreation, spiritual enrichment, cultural meanings, cognitive development, and reflection. For example, they include the opportunities offered by ecosystems for leisure activities, educational purposes, religious practices and recreation, as well as the cultural heritage value of ecosystems (Millennium Ecosystem Assessment (MEA), 2005[10]; Henriette, Neubert and Marrs, 2019[9])

Supporting services or functions include all the underpinning structures and processes that ultimately enable and support all other ecosystem services (such as nutrient cycling, soil formation and retention, habitat provision, etc.). They differ from provisioning, regulating, and cultural services as their impacts on humans are either indirect or occur over a long period of time, whereas changes in the other three categories have relatively direct, short-term visible impacts (Millennium Ecosystem Assessment (MEA), 2005[10]; Henriette, Neubert and Marrs, 2019[9])

By protecting, restoring, and enhancing the natural environment, GI can therefore support all these ecosystem services. The wide range of benefits it offers are comprehensively described in the technical document accompanying the 2013 EU Strategy on Green Infrastructure (European Commission, 2013[1]). These include positive impacts on people's health and well-being, recreational value, improved management of natural resources such as water, climate change adaptation and disaster prevention, GHG emissions reduction, biodiversity enrichment, low-carbon transport, air purification, and green job opportunities, among others (see Figure 2.1)

Figure 2.1. Benefits of GI



Source: (Henriette, Neubert and Marrs, 2019[9])

Health and well-being. GI is good for people's physical and mental health. For instance, parks and woodlands provide areas to relax and exercise, as well as to meet with others and carry out community activities. They promote social interaction and community cohesion. Moreover, they help reduce air pollution through the absorption, deposition, and dispersal of airborne pollutants, therefore enhancing air quality and producing positive impacts on human health. Trees further help mitigate noise pollution.

Natural resource efficiency. GI enhances the efficiency of natural resources. For example, it helps limit soil loss due to drying-out and erosion and maintains soil fertility. It also supports pollination and provides habitat for natural predators (e.g. hedgerows and wildflower strips in agricultural landscapes). Moreover, GIs safeguard freshwater resources through the creation of waterbodies (e.g. ponds and swales) and by increasing ground-water recharge through reducing rainfall run-off.

Water management. GI can improve water management in different ways. For example, it reduces the rate at which rainfall run-off enters the river network. This enables groundwater reserves to recharge rather than the water draining away through the river system in high volumes during rainfalls. Moreover, GIs protect waterbodies from pollution as they provide a sort of natural buffer between farmland and/or roads and any watercourse. As a result, they help control and limit agricultural and domestic discharges into waterbodies.

Education, tourism, and recreation. GI offers spaces for learning - whether formally or informally - and recreational activities. It provides opportunities to interact with nature to learn more about its key components and underlying processes, as well as to fully appreciate its value (OECD, 2021[2]).

Biodiversity conservation. GI contributes to the conservation of flora and fauna. It supports and enhances the network of interconnected habitats that flora and fauna need to thrive, guaranteeing opportunities for distribution, forage, and migration. An interconnected system of habitats facilitates genetic exchange with other populations and re-population of affected areas following disruptive events.

Climate change mitigation (i.e. reduced greenhouse gas (GHG) emissions) **and climate change adaptation** (i.e. increased resilience and capacity to adapt to the impacts of climate change). GI helps mitigate the impacts of extreme weather events and climate change. For example, it mitigates the heat-island effect in cities, providing cooling through shade and evapotranspiration from vegetation. It also helps mitigate the impacts of extreme temperatures, flooding, heavy rainfalls, landslides, droughts, and other extreme weather events. Moreover, GIs offer a number of options for carbon sequestration and storage from the atmosphere: more vegetation means more carbon stored in plants, animals, and soil.

Disaster prevention. In the near future, extreme weather events are expected to become more common. For example, the intensity and frequency of rainfalls will increase, and there will be a change in the distribution of rainfall across the globe (i.e. in some areas rainfall will be more intense, and in others, it will reduce). Well-planned GI helps cope with flood risks by offering options to regulate and store excessive rain flows. Moreover, it reduces the likelihood of landslides, given that vegetation and trees add stability to soils.

Land and soil management. GI has the power to limit moistures and soil losses as the soil becomes drier and more vulnerable to erosion due to climate change and increased frequency of extreme rainfall events. For example, green areas help soil to retain water and slow down the release of water.

Low-carbon transport and energy. GI promotes traffic-free, low-carbon and sustainable transport solutions (i.e. cycling and walking).

Resilience. GI fosters the capacity of biodiversity and ecosystems to be resilient and withstand long-term stresses, such as climate change. Moreover, it helps ecosystems to bounce-back from short-term disturbances (e.g. floods or fires). For example, coastal wetlands help regulate the water flow, prevent coastal erosion and reduce damages from storm surges and erosion. Furthermore, green areas and increased ecological connectivity bring opportunities for species' population to thrive, fostering intra-genetic variability and supporting biodiversity resilience (i.e. a species' ability to regenerate, recolonise or survive disturbances). The higher the intra-genetic variability, the more likely it is that the species will be resilient to external disturbances. Strong ecological connectivity across green spaces also facilitates the re-colonisation of an area that has suffered floods or fires, as it supports species migration.

Employment and investment opportunities. GI can stimulate the economy by creating jobs opportunities, much like investments in grey infrastructure. For example, the American Recovery and Reinvestment Act of 2009 financed coastal habitat restoration projects that yielded 17 jobs per million dollars invested (Edwards, Sutton-Grier and Coyle, 2013[11]). In the European Union, it is estimated that restoring 15% of degraded ecosystems would result in between 20 000 and 70 000 full-time jobs. Moreover, GI creates new opportunities for innovative businesses to thrive (OECD, 2019[12]).

Agriculture and forestry. GI does not only retain soil and limit moisture for agricultural land, but also fosters agricultural productivity. Most notably, woodland and riparian habitats support stable populations of pollinators and offer habitats to pest predators.

2.3. International regulations and policies relevant to GI and NbS

In recent decades, countries have paid growing attention to the need to address environmental degradation and the climate crisis. In this context, the adoption of GI and NbS has been increasingly promoted in the international arena to support climate change adaptation and mitigation, risk management and disaster prevention.

GI and NbS have been mentioned - more or less directly - in major global agreements, such as the Sendai Framework for Disaster Risk Reduction 2015 – 2030, the UN's 2030 Agenda for Sustainable Development, the United Nations Framework Convention on Climate Change (UNFCCC) and the 2015 Paris Agreement, the United Nations Convention on Biological Diversity (UNCBD), and the new Urban Agenda – Habitat III (see Table 2.1). All these global policy agreements recognise, at different levels, the potential of ecosystem-based approaches and the restoration of natural resources to achieve their policy objectives, including environmental, economic, and social goals.

Table 2.1. International policy agreements relevant to GI and NbS

Global policy agreement	Support to GI and NbS
Sendai Framework for Disaster Risk Reduction 2015 – 2030 (SFDRR)	The SFDRR recognises the role of ecosystems and environment as a cross-cutting issue in disaster risk reduction, emphasising that ecosystems need to be taken into account in risk assessments, risk governance, and resilience investments (UNDRR, 2015[13])
2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs)	Many of the SDGs include GI-related aspects and features, especially SDG 6, SDG 12, SDG 13, SDG 14, and SDG 15. For example, SDG 6 on clean water and sanitation aims to protect and restore water-related ecosystems and biomes, including mountains, forests, wetlands, rivers, acquirers, and lakes. SDG 14 and SDG 15, respectively on life below water and life on land, address the need to protect and restore marine and terrestrial ecosystems to halt biodiversity loss (European Environment Agency (EEA), 2021[14])
United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement	The UNFCCC promotes the use of ecosystem-based approaches to better manage extreme and slow-onset events, including loss of biodiversity and land degradation (UNFCCC, 2012[15]). Most notably, the Paris Agreement stresses the need to protect the integrity of ecosystems and biodiversity for climate change mitigation and adaption. Signatories of the Paris Agreement are also increasingly including nature-based solutions within their Nationally Determined Contributions (NDCs) (WWF, 2021[16]; European Environment Agency (EEA), 2021[14])
United Nations Convention on Biological Diversity (UNCBD)	Over the last two decades, the different outputs resulting from the Convention have promoted the use of NbS for biodiversity conservation, as well as for climate change adaptation and mitigation, and the sustainable use of natural resources. At COP 14, back in 2018, Parties have also agreed on "Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction", which also largely refer to GI and NbS (European Environment Agency (EEA), 2021[14]) Currently, a new post-2020 global biodiversity framework is being negotiated among Parties. Its adoption is scheduled for 2022, at COP 15. Among the new targets set for 2030, one specifically covers the use of NbS to ensure resilience and minimise any negative impacts on biodiversity
New Urban Agenda – Habitat III (endorsed in 2016)	The UN New Urban Agenda promotes the uptake of NbS and ecosystem-based approaches in several of its articles, emphasizing their key role to build an environmentally sustainable and resilient urban environment (United Nations, December 2016[17])

2.4. Green infrastructure for urban regeneration

Cities are at the forefront of environmental challenges. At the global level, they account for 75% of natural resource consumption and 60% to 80% of GHG emissions (Nature Squared, 2021[18]). At the same time, 70% of global urban areas are already facing the impacts of climate change, for example through increasing flooding, drought, and extreme heat events (Nature Squared, 2021[18]). These hazards are only likely to grow in the coming decades and make urban areas particularly exposed and vulnerable to their effects, due to the high density of population and physical assets they harbour (Frantzeskaki and McPhearson, 2022[19]).

To face these challenges, an increasing number of cities worldwide are developing and implementing different types of **urban green infrastructures and nature-based solutions**. These measures can take different forms, from public parks and urban forests to urban agriculture systems (e.g. urban farming and community gardens); from the use of permeable pavements and green drainage systems (e.g. rain gardens, bioswales) to the implementation of green roofs and walls; from the creation of water basins to the setup of green belts and corridors and nature conservation areas (Nature Squared, 2021[18]; OECD, 2021[8]).

Urban GI and NbS can produce several benefits simultaneously, thus representing effective strategies for addressing key environmental, social and economic challenges at once (OECD, 2020[20]; Fondazione per lo Sviluppo Sostenibile, n.d.[21]). They play a key role in preserving urban biodiversity while at the same time contributing to enhancing air, soil, and water quality (Fondazione per lo Sviluppo Sostenibile, n.d.[21]). For example, the Ecological Infrastructure project in the city of Antwerp (Belgium) aims at the conservation of 90 protected species (Xie and Bulkeley, 2020[22]), while in Mexico City, a network of green walls is primarily used to filter air pollution (Frantzeskaki and McPhearson, 2022[19]). Green belts built around urban areas can also help preserve biodiversity and ecosystem services, while at the same time containing sprawling development. GI and NbS also significantly enhance the climate resilience of urban areas, e.g. by reducing the impacts of flooding and heavy precipitation, drought, heatwaves, coastal storms, and sea-level rise (OECD, 2020[20]; Fondazione per lo Sviluppo Sostenibile, n.d.[21]; Frantzeskaki and McPhearson, 2022[19]). When maintained over significant amounts of time, certain green infrastructures can also contribute to reaching climate mitigation goals (OECD, 2020[20]; Fondazione per lo Sviluppo Sostenibile, n.d.[21]), containing GHG emissions while also enhancing carbon sinks (Girardin et al., 2021[23]). According to recent studies, urban GI and NbS have the potential to provide over one third of the greenhouse gas mitigation required by 2030 to keep global temperature increases within 2°C (Nature Squared, 2021[18]).

Beyond their many environmental benefits, well-planned green infrastructures and NbS also improve the liveability of cities and urban agglomerations, offering urban-dwellers healthy spaces for recreation, education, relaxation, as well as physical and social activities (Frantzeskaki and McPhearson, 2022[19]) (Nature Squared, 2021[18]). For instance, New York's High Line (i.e. an urban regeneration project primarily consisting of a walkable green roof) and the Ribeiro do Matadouro Park in Santo Tirso (Portugal) have both been associated with the increased physical activity and wellbeing of their users (Salih, Saeed and Almukhtar, 2021[24]) (Jo Black and Richards, 2020[25]). Overall, green infrastructures are usually associated with a lower incidence of respiratory, cardiovascular and other diseases (Cooper, 2021[26]). Finally, urban GI can also contribute to boost the local economy by creating employment and new business opportunities (Nature Squared, 2021[18]), attracting investments, and increasing the value of local assets (Nature Squared, 2021[18]) (Fondazione per lo Sviluppo Sostenibile, n.d.[21]). In New York City, for example, each additional hectare of urban GI is associated with an increase of nearly USD 12 thousand in neighbouring property values (Fondazione per lo Sviluppo Sostenibile, n.d.[21]). Overall, green urban areas have been associated with increases in the value of urban properties of between 5% and 15% (Ozment, Ellison and Jongman, n.d.[27]).

Besides offering many benefits at a lower economic and environmental cost (as compared to traditional grey infrastructure) (OECD, 2020[20]) ((n.a.), n.d.[28]), urban GI and NbS can also function as a complement to grey assets (Hallegatte et al., 2021[29]), enhancing their functions and lifespan as well as their resilience to climate extremes (OECD, 2020[20]).[3] For example, in Portland (USA), USD 9 million investments in the Green Streets Program (i.e. an urban network of permeable pavements and bioswales that aims at reinforcing the traditional water management and treatment facilities facing growing precipitation extremes) has allowed to save USD 224 million in water treatment infrastructure's repairs and maintenance (Ozment, Ellison and Jongman, n.d.[27]). Similarly, New York City's Green Infrastructure Plan aims to reduce water treatment costs by USD 2.4 billion over 20 years through the combination of traditional infrastructure with rain gardens, permeable pavements, and other green interventions (Fondazione per lo Sviluppo Sostenibile, n.d.[21]).

2.5. Green infrastructure in transport

In Italy, the transport system for people and goods is responsible for 25% of total GHG emissions, and 93% of these emissions come directly from road transport (Ministero delle infrastrutture e dei trasporti (MIT), 2022[30]). Moreover, transport infrastructure naturally takes up space in a country's landscape. Roads and railways connect the country but can interrupt nature and prohibit wildlife from crossing into different areas by separating habitats. Transport infrastructures are also sensitive to the impacts of climate change, especially to extreme weather events, such as floods, storms, wind gusts, etc. Moreover, given their size and costliness, transport infrastructures are not easy to replace. It is thus necessary to consider adaptation to climate change right from the outset of the planning and design process of transport infrastructures. Green infrastructure can assist in this, as the idea behind is to integrate the infrastructure asset into the existing landscape and ecosystems, thereby taking into account the risks that changing climate conditions can pose, as well as mitigating the infrastructure's impact on biodiversity.

There are numerous ways of integrating green elements into transport infrastructure. For example, NbS for roads and railroads entails green bridges and eco-tunnels over and under roads and railways. Another option is green noise barriers, shielding people and animals from traffic noise. Railways usually take up a significant amount of space – the rail corridor space. Using rail corridor space for vegetation can contribute to offset the carbon emissions of rail operations. Additionally, it offers a permeable surface for water and can help mitigate other climate impacts such as flood risk, water quality and soil erosion. An example of GI application on a railway is High Speed Two (HS2) in the United Kingdom. This line comprises two high-speed rail lines - one from London to Manchester and another from London to Leeds - built to support a modal shift from road to rail. Initially criticised for passing through green areas and splitting up wildlife habitats, the solution was to design an environmental corridor around the line, including by creating carbon-neutral stations, green bridges, and new wildlife habitats[4].

GI also offers opportunities for the urban transport sector. In cities and metropolitan areas, green transport infrastructure can take shape in the form of walking or cycling paths integrated with green spaces, such as parks or urban forests. These solutions tackle climate mitigation and adaptation challenges by promoting mode shift to active modes and providing natural solutions to prevent and mitigate the impacts of floods and droughts. Greening urban roads (i.e. using roadside vegetation) can help address heat island and water runoff problems, and result in better places for people (e.g. by creating public green space, improving public health and air quality), leading to beneficial social and environmental outcomes. Another NbS solution in the transport sector involves the development of green surfaces in parking spaces. In Edmonston, the United States, a NbS initiative for urban storm water management through bicycle lanes with permeable pavement and rain gardens on the town's main street has been developed. This initiative captures 90% of annual rainstorm water, provides better water quality, and filters airborne pollutants. Besides, the trees create shade in summer, contributing to fight the urban heat island effect in the area[5].

Several examples of successful integration of GI in transport policies and legislation also exist in Europe. For instance, DG Environment suggests including GI, specifically for climate change and biodiversity, in

Environmental Impact Assessments for transport projects and Strategic Environmental Assessments for transport plans/programmes[6]. The European Commission also supported GI development in Europe through the Interreg Transgreen Danube programme, which aimed at reducing landscape fragmentation by proposing GI measures for, among others, safe animal crossings.

Integrating GI in transport infrastructure planning is not only practised at a European level. Some EU countries have also prioritised such practices in their national transport systems planning, for example, Germany and Austria. Germany was an early adopter of the EU's Biodiversity Strategy. Germany adopted the Federal Defragmentation Programme in 2012 to maintain and restore GI across the national German road network. The "Green in Cities" initiative (started in 2015) includes the preparation of a "green paper" outlining the importance and multiple functions of urban GI as well as current challenges and perspectives related to GI, and a "white paper" (published in 2017) recommending actions to be taken to improve GI in Germany's urban areas. Another example is Austria, where constructing wildlife corridors is mandatory when new transport infrastructure crosses habitats[7]. This is applied in an action plan for the Alps-Carpathians Corridor[8], which is 120 km wide.

2.6. European regulations and policies for green infrastructure

At the European level, the policy framework governing GI is more advanced than in the broader international setting. It provides a definition for Green Infrastructure and promotes GI integration into EU policies to foster the achievement of EU policy objectives.

In 2013, the European Commission launched the first **EU Strategy on Green Infrastructure**, which highlighted the potential of GI and ecosystem-based approaches to foster regional cohesion, EU sustainable development, climate change mitigation and adaptation, disaster risk management, and the protection and restoration of natural capital in the EU. The Strategy aims at creating an enabling framework for GI implementation, to ensure they both become a standard ingredient of spatial planning and territorial development, even at the national level. It leverages a combination of policy signals and technical and scientific actions, which include: (i) integrating GI in key EU policy areas (e.g. regional cohesion, climate change and environmental policies, health and consumer policies, disaster risk management, and common agricultural policy); (ii) improving the mechanisms to collect and disseminate GI-related data information (e.g. information on the extent and condition of ecosystems, the services they provide, and the value of these services); (iii) strengthening the knowledge base and technical competencies for GI; (iv) promoting technological innovation to open new opportunities for GI implementation; (v) setting up innovative financing mechanisms (e.g. risk-sharing practices and multi-partner deals) that can address the complexity and risks of investing in GI; and (vi) integrating GI in EU projects. The Strategy also encourages the development of a Trans-European GI Network (TEN-G), which could mimic the role of existing networks in grey infrastructure sectors, such as transport, energy, and information and communication technology (ICT) (European Commission, 2013[1]). Many geographical assets, such as mountains, river basins and forests cross national boundaries and form part of the EU' shared natural heritage. Coordinated, joined-up actions and a pan-European vision are thus key to securing the resilience and vitality of some of the EU's most iconic ecosystems.

The development of a strategy on GI at the EU level was already envisaged in 2011 in the **EU Biodiversity Strategy to 2020**. The Biodiversity Strategy aimed at halting the loss in biodiversity and ecosystem services and included 6 policy targets and 20 specific actions to guide national and sub-national policies. In particular, Target 2 on "*maintain[ing] and restor[ing] ecosystems and their services*" sets out that "*[b]y 2020, ecosystems and their services [should be] maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems*". In addition, Article 6 of the Strategy encourages governments to "*[s]et priorities to restore and promote the use of green infrastructure*" (European Commission, 2011[31]).

In 2015, the European Union also released the **Natural Water Retention Measures (NWRM) platform**, which provides a comprehensive database of GI and NbS including technical specifications and over 100 case studies applications throughout the EU. The platform aims to support countries in addressing flood risk (OECD, 2021[8]).

In 2017, the European Commission drafted a **report to assess the progress made and difficulties encountered by the EU and its Member States in carrying out the 2013 Strategy on Green Infrastructure**. It identified the main lessons learned and put forward recommendations for the further implementation of the Strategy. Overall, the report revealed that there had been progress at various levels, but challenges still existed, and the deployment of GI needed to be further scaled up. Evidence showed that a strategic approach for GI at EU level had not been implemented yet, and that a more robust enabling framework for GI should be considered. GI were often only implemented at a small scale, not giving due recognition to the potential economic and social benefits of using green instead of (or in complement to) grey infrastructure. According to the report, at Member State level, increased effort is required to develop and implement national GI strategies and prioritisation frameworks for the restoration of degraded ecosystem. On financing, while the integration of GI into EU funding mechanisms had provided new opportunities, GI uptake was still too limited. Efforts should be stepped up to achieve effective mainstreaming of GI in relevant EU policies and legislation (European Commission, 2019[32]).

In 2019, the European Commission published **two guidance documents on green infrastructure** to help planners, policymakers and businesses solve socio-economic challenges while also protecting and restoring Europe's nature. One guidance document provided a **strategic framework for further supporting the deployment of EU-level green and blue infrastructure,** proposing an integrated approach to scaling-up investments on EU-level GI projects. The final aim was to improve the connectivity of Natura 2000 areas while also enhancing ecosystem services. The guidance also provided information on existing funding sources for green and blue infrastructure. The other document focused on encouraging the **integration of ecosystem considerations in decision-making**. It highlighted the wide range of benefits that result from ecosystem services and the possible ways to appropriately consider these benefits in policy, planning and business investment decisions (European Commission, n.d.[33]).

In recent years, GI has been increasingly integrated in EU policies and strategies. For example, the new **EU Biodiversity Strategy to 2030** encourages European cities with more than 20 thousand inhabitants to adopt urban green plans by 2021, which include the creation of accessible and biodiversity-rich forests, parks and gardens, green roofs and walls, tree-lined roads, meadows and hedges. Urban green plans should help improve the connectivity across urban and peri-urban green spaces, and regulate socio-economic practices harmful to biodiversity (e.g. excessive mowing, the use of pesticides, etc.) (European Commission, 2020[34]). Moreover, one of the key deliverables of the EU Biodiversity Strategy to 2030 is the **new EU Strategy for Soil to 2030**, which defines the framework and concrete measures to protect and restore soils, and ensure they are managed sustainably. The Strategy highlights also the need to coordinate water and soil policies to achieve healthy soils and aquatic ecosystems through better soil and water management. It recommends Member States to integrate soil and land use management in the river basin and in flood risk management plans by levering NbS, such as protective natural features, landscape feature, river restoration, floodplains, etc (European Commission, 2021[35]).

The **EU Action Plan on the Sendai Framework** for Disaster Risk Reduction 2015-2030 promotes NbS as a positive and cost-efficient solution for the conservation, enhancement, and restoration of biodiversity and ecosystem services in urban, rural, coastal and natural areas. Moreover, it highlights their potential to provide additional co-benefits (e.g. on well-being, safety, health, etc.) (European Commission, 2016[36]; European Environment Agency (EEA), 2021[14]).

The 2019 **European Green Deal** provides explicit support to NbS as an effective measure for climate change adaptation and disaster risk reduction. Most notably, it emphasises the key role of ecosystems and their ability to provide essential services, including mitigating the risk and impacts of natural disasters and regulating the climate (European Environment Agency (EEA), 2021[14]).

The 2021 **EU Strategy on Adaptation to Climate Change** aims at fostering the continent's adaptation to climate risks and impacts, ensuring climate resilience by 2050. The Strategy encourages adaptation interventions that are smarter, swifter and more systemic, and advocates for the need to step up international action on adaptation to climate change. The European Commission is committed to support the development and implementation of adaptation strategies and plans at all levels of government by pursuing three cross-cutting priorities: (i) integrating climate change adaptation into macro-fiscal policy, (ii) scaling-up the adoption of NbS, and (iii) promoting the implementation of local adaptation actions (European Commission, 2021[37]).

2.7. The EU taxonomy and the Do No Significant Harm principle

In the EU, the integration of GI in infrastructure planning, project design and implementation has been further promoted by **the EU Taxonomy** and the **Do No Significant Harm (DNSH) principle**. These instruments ensure infrastructure investments contribute to environmental and climate targets and cause no significant harm to the environment, therefore promoting considerations of ecosystem services, biodiversity protection and ecological connectivity.

With the scope to support the achievement of ambitious green goals and guarantee that public and private initiatives effectively contribute to sustainable development, in June 2020, the EU issued the Taxonomy Regulation (EU Regulation 2020/852), which identifies six climate and environmental objectives, namely (European Parliament and The Council of the European Union, 2020[38]):

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Transition to the circular economy
5. Pollution prevention and control
6. Protection and restoration of biodiversity and ecosystems

The Taxonomy also outlines the four overarching conditions an economic activity must meet in order to qualify as "environmentally sustainable".

1. It should contribute substantially to one or more of the climate and environmental objectives;
2. It should not significantly harm any of the other objectives (DNSH);
3. It has to be carried out in compliance with minimum social safeguards - defined in the EU Regulation 2020/852[9];
4. It must comply with the technical screening criteria established through Delegated Acts by the European Commission .

In February 2021, the European Commission published the **Technical Guidance on the application of DNSH** in order to support Member States in the development of their National Recovery and Resilience Plans (NRRP) and ensure that none of the measures (i.e. reforms or investments) included caused significant harm to the six environmental objectives identified in the Taxonomy (European Commission, 18 February 2021[39]) (see Box 2.2). The Guidance sets out the approach, criteria, and tools countries should rely on to demonstrate compliance with DNSH. For the integration of GI, DNSH compliance for two environmental objectives is particularly relevant: **climate change adaptation and protection of biodiversity and ecosystems**.

The Technical Guidance considers an activity to cause a "significant harm" to climate change adaptation when it leads to an increased adverse impact of the current climate and the expected future climate, on the activity itself or on people, nature, or assets. This can occur either by not implementing the necessary solutions to withstand climate change risks (i.e. building in a flood-prone area), or by maladaptation. Maladaptation consists in the implementation of adaptation solutions to certain risks, which nonetheless increase vulnerability or exposure to other risks. To demonstrate compliance with the DNSH for climate change adaptation, Member States can rely on a suggested (non-comprehensive) list of supporting evidence that includes a climate vulnerability and risk assessment[10]. Climate vulnerability and risk assessments should identify the physical climate risks that might affect the activity during its expected lifetime and assess the materiality of the risks on the activity itself. Moreover, it should include the identification, appraisal, and implementation of relevant adaptation measures to reduce the physical risks, and that integrate the use of nature-based solutions or rely on green and blue infrastructure (European Commission, 2021[40]; European Commission, 18 February 2021[39]).

In terms of protection of biodiversity and ecosystems, an activity is considered as non-compliant with the DNSH principle if it is significantly detrimental to the good condition and resilience of ecosystems, or detrimental to the conservation status of habitats and species. For example, measures that give rise to land fragmentation and degradation issues or cause disturbance to protected sites, habitats, and protected animal species do not comply with the DNSH principle. In this case, countries are expected to perform an environmental impact assessment of the specific measure and integrate the required mitigation and compensation measures in project design. These can include building green corridors and other habitat connectivity measures to limit land fragmentation and degradation, avoid disturbance to protected animal species and ensure new infrastructures are not located in or near biodiversity-sensitive areas such as, Natura 2000 sites, UNESCO World Heritage sites, Key Biodiversity Areas[11] and other protected areas (European Commission, 2021[40]; European Commission, 18 February 2021[39]).

Box 2.2. Technical guidance on the application of the DNSH

In response to the Covid-19 pandemic, the European Union launched the **Next Generation EU Plan (NGEU)**, an economic recovery package worth more than EUR 800 billion to support Member States to recover from the impacts of the pandemic. The NGEU's centrepiece is the **Recovery and Resilience Facility (RRF)**, which provides EUR 723.8 billion in grants and loans to finance the implementation of reforms and investments that align with the objectives of the Paris Agreement, the UN 2030 Agenda, and the European Green Deal. Given the large social and economic impacts suffered during the pandemic, Italy is one of the largest beneficiaries of the RRF, with an estimated total allocation of approximately EUR 191 billion to support the implementation of its NRRP.

As required by the RRF Regulation, the measures (i.e. reform and investment) included in countries' NRRP shall cause no significant harm to any of the six environmental objectives outlined in the EU Taxonomy. To support compliance, the European Commission published the Technical Guidance on the application of DNSH in February 2021. The Guidance clarifies the meaning of DNSH principle, and how it should be applied in the context of the RRF. It also defines the procedure Member States should follow to demonstrate their proposed measures comply with DNSH. Concrete worked out examples are provided in the Annex IV to the guidance.

Source: (European Commission, n.d.[41]; European Commission, 18 February 2021[39]; Governo Italiano, n.d.[42])

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Notes

1 At the international level, the term “NbS” has been defined as “*measures that protect, sustainably manage or restore nature, with the goal of maintaining or enhancing ecosystem services to address a variety of social, environmental and economic challenges*” (OECD, 2021[8]). In this sense, GI and NbS refer to similar concepts, centred on supporting ecosystem services and biodiversity. For the purpose of this report and in order to be consistent with the use of GI and NbS in the Italian context, the term “NbS” will be used to identify specific project solutions.

2 The term “grey infrastructure” refers to man-made engineered infrastructure, such as dams, dikes, seawalls, roads, pipes and water treatment plans (OECD, 2020[20]).

3 This mix – usually referred to as green-grey or hybrid infrastructure – is particularly relevant in light of the growing climate impacts on infrastructure systems (Hallegatte et al., 2021[29]; Ministero delle infrastrutture e dei trasporti (MIT), 2022[30]).

4 https://www.hs2.org.uk/why/carbon/

5 EC DG ENV, ENV.B.2/SER/2014/0012 “Supporting the implementation of the European Green Infrastructure Strategy”

6 Ibid

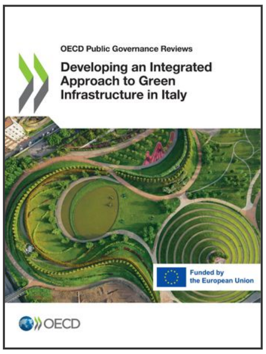
7 Richtlinie Wildschutz 2007

8 https://ec.europa.eu/regional_policy/en/projects/austria/innovative-alps-carpathians-corridor-re-establishes-a-major-migration-route-for-wild-animals

9 *A first delegated act on sustainable activities for climate change adaptation and mitigation objectives* was published in the Official Journal on 9th December 2021 and is applicable since January 2022. A second delegated act for the remaining objectives will be published in 2022.

10 Appendix A of Annex 1 to the EU Regulation 2020/852 defines the procedure for climate vulnerability and risk assessment. It also includes a list and classification of the climate-related hazards to consider, such as changing temperature, changing wind and precipitation patterns, coastal erosion, heat stress, soil degradation, saline intrusion, drought, flood, wildfire, etc. (European Commission, 2021[40]).

11 Key Biodiversity Areas (KBA) are sites contributing significantly to the global persistence of biodiversity in terrestrial, freshwater and marines ecosystems. (International Union for Conservation of Nature (IUCN), n.d.[43])



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