OECD Public Governance Reviews

Developing an Integrated Approach to Green Infrastructure in Italy

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Foreword

Climate change will affect the frequency and intensity of extreme weather events and natural hazards (such as floods, droughts, and fires), causing physical damage, economic loss, and social and environmental disruption across all regions of the world. In Italy, climate-induced extreme events have had severe impacts on different infrastructure networks, such as metros, train lines and electricity grids. The direct economic impact of climate change on infrastructure assets in Italy is projected to increase around twelve-fold by 2050, up to EUR 5.17 billion per year.

As part of its efforts to achieve sustainability and resilience objectives, and as part of its recovery from the pandemic, Italy would like to strengthen the role of two instruments in spatial and infrastructure planning: green infrastructure (GI) and nature-based solutions (NbS). These instruments can help safeguard biodiversity conservation and ecosystem services (the goods and services that nature provides and that are essential to life), strengthen ecological connectivity across green areas, and enhance societal resilience to climate change.

This report provides an overview of the current practices to integrate environmental and climate considerations in spatial and infrastructure planning in Italy. It provides examples on good practices to integrate GI planning in territorial development, identifies the main challenges and provides policy recommendations to promote the widespread implementation of GI and NbS in Italy.

GI and NbS remain relatively new concepts in the infrastructure field, and the lack of a solid knowledge base and technical skills among practitioners and public officials represents one of the major hurdles to increasing their use. Drawing on international good practices, this report proposes an integrated approach to GI and NbS in Italy, which may also be of interest to other countries. The approach looks at the entire lifecycle of an infrastructure project, considers the main trade-offs concerning GI and NbS, and proposes solutions to integrate them in the planning, appraisal, financing, procurement, and maintenance of infrastructure investments in Italy.

This report is part of a broader initiative aimed at strengthening Italy's institutional and administrative capacity, including at regional and local levels, to facilitate socially inclusive, green and digital transitions. It will also contribute to OECD work on green and resilient infrastructure. The action was funded by the European Union via the Technical Support Instrument and implemented by the OECD in co-operation with the Directorate-General for Structural Reform Support of the European Commission.

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The report was written by Ana Maria Ruiz Rivadeneira (IPP), Ludovica Mager (IPP), Marta Arbinolo (ETR), Catherine Gamper (ETR), Guineng Chen (QPA), Maya Ter Laag (QPA), Raffaele della Croce (IPP), Guendalina Bettinelli (ETR), and Giulia Bonazzi (ETR). The report also benefitted from comments and inputs provided by Mauro Sibilia, policy officer from DG Reform at the European Commission, and by Bernardette Veca (DG), Donato Lamacchia (PO), Sebastiano Alvise Rota (PO), Carla Peduto (PO) and the Technical Assistance of the Directorate General for Territorial Development, Planning of International Projects of the Italian Ministry of Infrastructure and Transport. The Ministry of Environment and Energy Security, the Ministry of Culture, Reti Ferroviarie Italiane, sub-national authorities and regional environmental protection agencies (e.g. from Lombardia and Emilia-Romagna), and representatives of Legambiente also provided valuable input.

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Abbreviations and acronyms

APPA	Provincial agencies for environmental protection
ARPA	Regional agencies for environmental protection
ARPAE	Environmental protection agency of Emilia-Romagna
CAP	Common agricultural policy
CBA	Cost-benefit analysis
CEA	Cost-efficacy analysis
CIPESS	Inter-ministerial committee for economic planning and sustainable development
CTP	Co-ordination territorial plan
DNSH	Do no significant harm
EC	European Commission
EIA	Environmental impact assessment
EIS	Environmental impact study
EN	Ecological network
GAIA	Green area inner0city agreement
GDP	Gross domestic product
GHG	Greenhouse gas emissions
GI	Green infrastructure
GPP	Green public procurement
GUP	Green urban plan
ISPRA	Higher institute for environmental protection and research
KPI	Key performance indicators
LEN	Local ecological network
LUP	Local urban plan
MASAF	Ministry of agriculture, food sovereignty and forestry
MASE	Ministry of environment and energy security
MCA	Multi-criteria analysis
MEC	Minimum environmental criteria
MIT (previously MIMS)[1]	Ministry of infrastructure and transport (previously Ministry of sustainable infrastructure and mobility)
MoC	Ministry of Culture
NAP	National action plan
NbS	Nature-based Solutions
NOP (I&N)	National operational programme (for infrastructure and networks)
NRRP	National Recovery and Resilience Plan
PEN	Provincial ecological network
PEFT	Technical and economic feasibility project
PES	Payment for ecosystem services
PINQuA	National innovative programme for high-quality living

[1] Under the previous minister Enrico Giovannini, the ministry's name was changed to "*Ministry of sustainable infrastructure and mobility*" (or MIMS). Since November 2022, under the leadership of the new minister Matteo Salvini, the name of the ministry is "*Ministry of infrastructure and transport*" (or MIT).

REN	Regional ecological network
RLP	Regional landscape plan
RRF	Recovery and resilience facility
RTP	Regional territorial plan
RWPP	Regional water protection plan
SEA	Strategic environmental assessment
SECAP	Sustainable energy and climate action plan
SIMS	Scoring system for sustainable infrastructure and mobility
SNPA	National network system for environmental protection
SPoMC	Strategic plan for the metropolitan city
SUMP	Sustainability urban mobility plan
TEN-T	Trans-European transport network
TPP	Territorial provincial plan

Executive summary

According to the 2022 IPCC Assessment Report, greenhouse gas emissions (GHG) increased across all major economic sectors globally between 2010 and 2019, making the climate crisis more urgent than ever. Climate change is also likely to have an impact on infrastructure networks, which are the backbone of any modern society (i.e. water and energy systems, telecommunication, transport, health, etc.). In Italy, the infrastructure system is particularly vulnerable to climate-induced extreme events. For example, between 2010 and 2021, subways and urban trains in major Italian cities were closed for a total of 83 days (29 days in Rome, 19 in Milan, 15 in Naples, 12 in Genoa, etc.), while extreme weather conditions disrupted electricity networks for a total of 89 days. For this reason, developing an infrastructure governance system capable of managing today's environmental challenges while strengthening resilience to climate change is key to ensure Italy's sustainable and resilient future.

Green infrastructure (GI) and nature-based solutions (NbS) are powerful instruments that can be harnessed to this end. In this report, GI is considered as a planning instrument to ensure that the protection of biodiversity, ecosystem services and ecological networks are considered, from the outset, in territorial and infrastructure development. The term "NbS" refers to specific project-level solutions, including the use of natural materials and the integration of mechanisms that mimic nature in infrastructure projects (e.g. the integration of green walls or roofs in buildings, or the use of permeable rather than impermeable pavement to improve water absorption and retention to mitigate the effects of heavy rains).

Both instruments are gaining attention in Italy. Unlike single-purpose, grey infrastructure, they can perform several functions simultaneously and at very low comparative cost, creating benefits for people, nature, and the economy. Nonetheless, the consideration and uptake of GI and NbS remain limited due to implementation challenges. Some of these challenges are linked to the intrinsic characteristics of GI, while others are related to an inadequate enabling environment (e.g. institutional, regulatory, and financing frameworks, as well as technical capacity).

OECD proposed integrated approach to green infrastructure

Building on international good practices and lessons learned, the OECD proposes an integrated approach to GI and NbS. This approach considers all the main trade-offs concerning GI and NbS and proposes solutions to integrate them in the planning, appraisal, financing, procurement, and maintenance of infrastructure investments. It is based on six pillars:

1. Define a sound institutional framework for GI that encourages co-ordination, provides a clear definition of roles and responsibilities, sets out guidance and develops technical skills for implementation.
2. Integrate GI in regulatory and planning instruments, both at the national and sub-national level.
3. Make use of existing funding instruments or develop new ones to promote GI.
4. Promote NbS in project planning, appraisal, and prioritisation using a combination of traditional appraisal tools and non-traditional methods.

5. Develop tools and strategies for governments and public buyers to facilitate the procurement of NbS.
6. Provide monitoring and maintenance of infrastructure projects across their lifecycle to ensure they fully deliver the expected results and intervene as needed.

GI and NbS in Italy

Italy has long-standing experience with environmental protection and the management of ecological networks. Regulatory frameworks and instruments for spatial planning already consider the potential impacts of territorial development on the environment and ecological networks to limit the expected negative impacts and reinforce positive ones. Moreover, GI and NbS are increasingly mentioned in key policy documents and strategies, including the National Biodiversity Strategy 2030. Nonetheless, more needs to be done if the country is to become a frontrunner in the adoption of a GI-integrated approach to infrastructure governance. While some isolated good practices exist at the subnational level, a more consistent adoption of these two instruments across the whole national territory is needed.

GI and NbS involve different levels of government, which often creates hurdles in their implementation. At the central level, the main administrations involved (MIT, the Ministry of Environment and Energy Security and the Ministry of Culture) tend to have different roles and responsibilities, which sometimes overlap. Moreover, in the absence of central-level guidance, subnational authorities (regions, municipalities, and metropolitan cities) are often responsible for integrating these two instruments in territorial development and infrastructure projects, with some regions and cities performing better than others.

At the project level, there are different tools in place to integrate environmental considerations in infrastructure planning and design, in project appraisal, and in the financing and delivery of public investment projects. However, these instruments often fail to promote the use of GI and NbS and could be further refined to integrate considerations of biodiversity and ecosystem protection and restoration.

Main recommendations for fostering GI and NbS implementation in Italy

Despite MIT's recent efforts to promote sustainability in public investment decisions, there is room for improvement for Italy to integrate GI in spatial planning and ensure a more widespread uptake of NbS in infrastructure projects across the national territory. Based on the challenges identified and the lessons learned from the selected case studies (e.g. the railway line Bicocca-Catenanuova, the metro line M4 in Milan, the Nodo Verde ("Green Node") in Bari, and the Ridracoli Dam in Emilia-Romagna), the OECD has developed a series of recommendations to help the Ministry promote GI and NbS across all levels of government:

1. **Define a policy and regulatory framework that enable GI**. Italy has sound sustainability requirements for infrastructure plans and projects; however, the notion of sustainability does not explicitly consider GI. The Italian government could consider developing a policy and regulatory environment for the uptake of GI in infrastructure planning and NbS in project planning, including the full consideration of the ecosystem and the long-term benefits that these tools have to offer.
2. **Define an institutional setup for GI, including clear roles and responsibilities and co-ordination mechanisms across key stakeholders**. In the current institutional setup governing GI in Italy, many actors are involved in planning and implementation, but their roles and responsibilities often overlap. It is important to define a common reference framework that assigns clear tasks and responsibilities. Co-ordination is important to promote coherence and synergies across the different initiatives relevant for GI, as well as to address the trade-offs. A cross-sectoral and cross-governmental approach is needed to raise awareness, enhance technical capacity, and improve the policy and regulatory environment.

3. **Build a knowledge base and technical competences**. Knowledge and technical capacities vary among people working at different levels of government. Uncertainty around GI and NbS often results in a tendency to favour traditional grey infrastructure. Italy would benefit from better understanding and raising awareness of the potentials and limitations of GI and NbS, as well as of how to effectively implement them. A first step would be to develop a specific analysis of Italy's natural assets, map the risks local territories are likely to face, consider how future scenarios could affect NbS and GI, and design methods to monitor their lifecycles.

1 Relevance of green infrastructure in Italy

The climate crisis has increased the average global temperature and is leading to more frequent high-temperature extremes across the globe. In Italy, the infrastructure network has already suffered serious damages and losses, and the impact of climate change on infrastructure assets is projected to increase. Mainstreaming climate change considerations in the decision-making process for public investments is more urgent than ever. In particular, green infrastructure and nature-based solutions can be used as instruments to steer the infrastructure sector into a more sustainable and resilient path.

Today, **Italy must take urgent action to mitigate climate change and adapt to its impacts**. Climate change will affect infrastructure assets, disrupting the services they offer and threatening the stability of social and economic networks. Even though the year 2021 was not as hot as the previous ones, heat waves hit the Italian peninsula over the summer period, with the most intense one reaching 48.8 ºC in Syracuse, Sicily. Heavy rainfalls also occurred, especially in the Liguria region, causing floodings, landslides, and mudslides. In October, a tropical cyclone in the Mediterranean Sea brought heavy rains in the southern regions of the country, resulting in the flooding of rivers and canals (Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), 2021[1]). In between 1st January and 1st November, Italy faced 133 extreme-weather and climate-related events, which caused major impacts in several regions and cities. Climate-induced extreme events have severe impacts on infrastructure networks, such as metros, train lines and electricity grids. For example, between 2010 and 2021, subways and urban trains in major Italian cities have been closed for a total of 83 days (29 days in Rome, 19 in Milan, 15 in Naples, 12 in Genoa, etc.), while electricity networks have been subject to widespread disruptions for a total of 89 days due to extreme weather conditions (Legambiente, 2021[2]). A recent report coordinated by the Ministry of Infrastructure and Transport (MIT)[1] investigates current and future climate change impacts on transport infrastructure, both at the national and local level (see Box 1.1). According to the report's estimates, the direct economic impact of climate change on infrastructure assets in Italy is projected to increase up to EUR 5.17 billion per year by 2050, which represents an increase of about 12 times compared to the value of current damages (Ministero delle infrastrutture e dei trasporti (MIT), 2022[3]).

In order to make infrastructure resilient to climate change and implement effective adaptation strategies, MIT has committed to the "*transformative resilience*" approach. The latter aims to go beyond the traditional way of responding to the climate crisis with ad-hoc measures and adopts a more systemic and integrated approach. This approach leverages "*green*" measures, i.e. solutions that build on nature and the multiple benefits provided by ecosystems to enhance the resilience and adaptive capacity of infrastructure assets (Ministero delle infrastrutture e dei trasporti (MIT), 2022[3]).

In its National Recovery and Resilience Plan (Piano Nazionale di Ripresa e Resilienza, PNRR), Italy allocates 37.5% of the EU funds made available through the Next Generation EU Plan to actions that can help the country achieve its climate goals. It also outlines substantial measures and investments that will contribute to environmental goals, biodiversity protection, the restoration of ecosystem services[2], and improvements in natural resource management. These cut across different sectors, including infrastructure for transport, energy, public buildings, water, etc. (European Commission, 2021[4]). In other words, through the PNRR, the country aims to steer the infrastructure sector onto a greener trend.

In this context, developing an **infrastructure governance system that is prepared to manage the environmental challenges of our time** is key to enhance and protect the country's natural capital, while at the same time also strengthening resilience to climate change. Doing so also provides an opportunity to rethink public infrastructure investments and strengthen risk management, not least by strengthening preventative measures, risk awareness, and emergency preparedness against climate risks such as heatwaves, windstorms, wildfires, floods, landslides, drought, extreme precipitation, soil erosion, and so on.

Box 1.1. Climate change, infrastructure, and mobility in Italy

The "Climate change, infrastructure and mobility" report published in 2021 by the Carraro Commission investigates current and projected climate change impacts on Italian transport infrastructure at both the national and local level. Building on this information, it sets out a number of recommendations to best manage changing climate conditions, both in terms of adaptation (i.e. to increase resilience and adapt to the impacts of climate change) and mitigation (i.e. to reduce greenhouse gas emissions), with a thorough territorial approach. Below follows a collection of the main facts and data from the report.

Climate risks and impacts

- **Climate change poses serious constraints to Italy's economic growth** and is projected to cause a GDP loss of up to 2% by 2050 under a +2ºC warming scenario. Under a +2.7ºC warming scenario, GDP losses are projected to reach 2.5%, while under a +4.4ºC warming scenario, GDP losses could reach 3.7%.
- **Climate change is also projected to have a growing impact on society and human well-being**. Changing climate conditions are projected to increase the mortality rate by 86-137% (under RCP 4.5[3]), mainly due to a rise in the number of premature deaths from extreme weather events, such as for example heatwaves, floods and wildfires. Climate change is also likely to reduce work productivity and exacerbate existing regional and socio-economic differences.
- **The physical impacts of climate change are likely to become more frequent and more extreme.** In the coming decades, the frequency and intensity of extreme weather events is projected to grow, with more frequent windstorms, more intense and frequent extreme precipitation events (especially in Italy's central and northern regions), more extreme coastal storms (especially in the upper Adriatic and upper Tyrrhenian seas), longer and more intense heatwaves, wildfires, and droughts, as well as more intense river floods. Southern regions are projected to experience particularly extreme drought events, with Sardinia and Calabria projected to experience the most pronounced worsening of drought conditions of the country.

Climate change and infrastructure

- **By 2050, the direct economic impact of climate change on infrastructure is expected to increase up to EUR 5.17 billion per year**, which corresponds to an increase of about 12 times compared to current damage estimates. Overall, in the absence of adaptation measures, the total damage to infrastructure – including both the direct and indirect impacts of climate change - is projected to reach 0.33% to 0.55% of Italy's GDP in 2050.
- Today, the majority of the climate-related damages to infrastructure in Italy are due to riverine flooding. Yet the relative amount of damages caused by droughts and heatwaves is projected to increase, accounting for about 92% of the projected climate damages by 2041-2070[4], compared to an observed 31% over the period 1981-2010
- In economic terms, climate impacts on infrastructure are likely to be more pronounced in the northern and Tyrrhenian regions of the country, as these host a higher concentration of infrastructure assets.

Source: (Ministero delle infrastrutture e dei trasporti (MIT), 2022[3])

1.1. The urgency of climate change and the need for climate-proofing infrastructure

According to the latest IPCC Assessment Report (AR6), greenhouse gas emissions (GHG) have increased across all major economic sectors globally in the period between 2010 and 2019 (IPCC, 2022[5]). Most notably, CO_2 emission reductions from fossil fuels and industrial processes – linked to improvements in the energy intensity and in the carbon intensity of energy – have not been sufficient to compensate for the emission increases resulting from rising global activity levels in industry, energy supply, transport, agriculture and buildings. Based on the Nationally Determined Contributions (NDCs) submitted by countries to date, global GHG emissions will keep increasing, making it likely for global warming to exceed 1.5°C by 2030. The need to limit global warming to 1.5°C and well below 2°C thus calls for a rapid acceleration of global GHG mitigation efforts (IPCC, 2022[5]).

At the same time, larger adaptation efforts are needed. In its analysis on climate change adaptation, risks, and vulnerability, the latest IPCC report shows that the extent and magnitude of climate risks and impacts will likely be larger than estimated in previous assessments. Changing climate conditions and extreme weather events are already causing physical damages, economic losses, as well as social and environmental disruption across all regions of the world. Observed and projected impacts include among others biodiversity loss, substantial damage and disruption to ecosystems and their services, the retreat of glaciers (with the ensuing challenges, e.g. to freshwater security), increase in heat-related human mortality, challenges to food security, damages to settlements and infrastructure, adverse impacts on the physical and mental health of people, increased occurrence of climate-related food-borne and water-borne diseases, and disruption of key societal services. Some of these impacts are already locked in and irreversible. Climate risks and their impacts are also becoming increasingly complex and difficult to manage. Indeed, multiple climate hazards are expected to occur simultaneously and exacerbate other non-climatic hazards (e.g. land subsidence in coastal areas, decreasing biodiversity, etc.), compounding existing pressures and generating cascading impacts across sectors and regions (IPCC, 2022[6]).

In this context, climate change will add to and amplify existing chronic infrastructure challenges, such as limited funding, poor maintenance and mismanagement. If not adequately managed, climate change will affect the physical integrity of infrastructure assets and reduce the quality, continuity, and reliability of infrastructure services, resulting in poorer water quality and sanitation, faulty transport networks, unreliable electricity grids, etc. (OECD, 2021[7]).

According to the 2020 OECD Survey on Infrastructure Governance, countries are leveraging **enhanced infrastructure investments as a stimulus measure** in their recovery from the Covid-19 pandemic. Although the latest data were collected in January 2021, with the pandemic still unfolding, 21 OECD countries (70% of the 30 surveyed) had already adopted an economic stimulus or recovery package. Of these, over three-quarters see infrastructure playing a key role in the recovery. For instance, in Chile, Costa Rica, Hungary, Ireland, New Zealand and Slovenia, 30% or more of the economic stimulus package has been allocated to investments in infrastructure (OECD, 2020[8]). This represents a one-off opportunity to steer the infrastructure sector onto a more resilient and sustainable path. For this reason, governments are called upon to take advantage of the recovery from the pandemic to **climate-proof their infrastructure**, which requires integrating climate change adaptation and mitigation considerations into the design, development, and management of spatial planning and infrastructure projects, including both new and existing assets (European Commission, 2021[4]).

In this context, **green infrastructure (GI)** has gained increased attention as an instrument to support biodiversity conservation, strengthen the ecological connectivity across green areas, enable the protection and restoration of terrestrial and marine ecosystems and their services, and enhance societal resilience to changing climate conditions and extreme weather events.

1.2. The project's objectives

Given the urgency of the climate crisis and the climate risks faced by Italy, the Ministry of Infrastructure and Transport (MIT)[5] is committed to improve the management of infrastructure by strengthening environmental and climate considerations. MIT aims to ensure that all infrastructure that falls under its competency – including urban assets, buildings, roads, railways, water infrastructure, ports and airports, etc. - all contribute to the reduction of GHG emissions and to build a more resilient society – not least, by developing infrastructures that are themselves resilient to the impacts of climate change, as well as to other environmental challenges.

Mainstreaming environmental sustainability and climate change considerations in the management of existing assets and in the development of new infrastructure projects requires a good understanding of climate risks and improved governance mechanisms throughout the entire infrastructure asset lifecycle.

With the support of the European Commission under the **Technical Support Instrument** (TSI) **Regulation** (Regulation 2021/240), the OECD aims at providing technical support to MIT in the area of infrastructure governance. In the context of this TSI project, this report defines an integrated approach to strengthen the planning and financing of green infrastructure (GI) and promote the use of nature-based solutions (NbS) in project design and implementation in Italy.

It is important to note that at the international level the terms GI and NbS refer to concepts centred on supporting ecosystem services and biodiversity. For the purpose of this report and in order to be consistent with the use of the terms of GI and NbS in the Italian context, the term GI will be used as a planning instrument to ensure that the protection of biodiversity and ecosystem services as well as ecological networks are considered, right from the outset, in territorial and infrastructure development. On the other hand, the term "NbS" will be used to refer to specific project-level solutions.

The report builds on desk research conducted by the OECD, on the responses to the OECD questionnaire provided by the three Italian Ministries involved[6], and on the information gathered during the OECD's fact-finding mission in Rome[7]. The report also includes four case studies to showcase how GI and NbS are currently implemented in Italy: (i) the railway line from Bicocca to Catenanuova (Sicily), (ii) the Green Node (i.e. *Nodo Verde*) in Bari (Puglia), (iii) the Metro 4 line in Milan (Lombardy), and (iv) the Ridracoli Dam in Emilia-Romagna (see chapter 4)[8].

The report is organised as follows: chapter 2 provides a conceptual framework and an overview of the state-of-the-art of GI and NbS at the international level. Chapter 3 highlights international good practices in the implementation of GI and NbS and provides an integrated approach to strengthen GI consideration in infrastructure planning and decision-making processes. Chapter 4 identifies the main challenges and opportunities to foster GI and NbS implementation in Italy. Finally, chapter 5 summarizes the main conclusions of the report and outlines key recommendations to support the effective implementation of the proposed integrated approach in Italy. Throughout the report, due attention is paid to the existing regional differences that characterise the Italian landscape, and two main sectors are investigated: urban regeneration and transport.

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Notes

[1] The report was drafted by the European Commission on "Climate change, infrastructure and mobility", which was established by the previous minister Enrico Giovannini in April 2021 and supervised by professor Carlo Carraro. Under the previous minister Enrico Giovannini, the ministry's name was changed to "*Ministry of sustainable infrastructure and mobility*".

[2] 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]).

[3] RCP4.5 is an IPCC climate scenario based on greenhouse gas concentrations in the atmosphere. It is considered an intermediate scenario, likely to lead to temperature increases of 2 to 3ºC.

[4] This estimate refers to a +3ºC warming scenario.

[5] Under the previous minister Enrico Giovannini, the Ministry's name was changed to "Ministry of sustainable infrastructure and mobility". Since November 2022, under the new minister Matteo Salvini, the name of the Ministry is "Ministry of infrastructure and transport".

[6] The Ministry of Infrastructure and Transport (MIT), the Ministry of Environment and Energy Security (MASE), and the Ministry of Culture (MoC).

[7] The fact-finding mission took place in Rome on 20th and 21st July 2022.

[8] The case studies were selected with the purpose to cover different regions of the country.

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]).

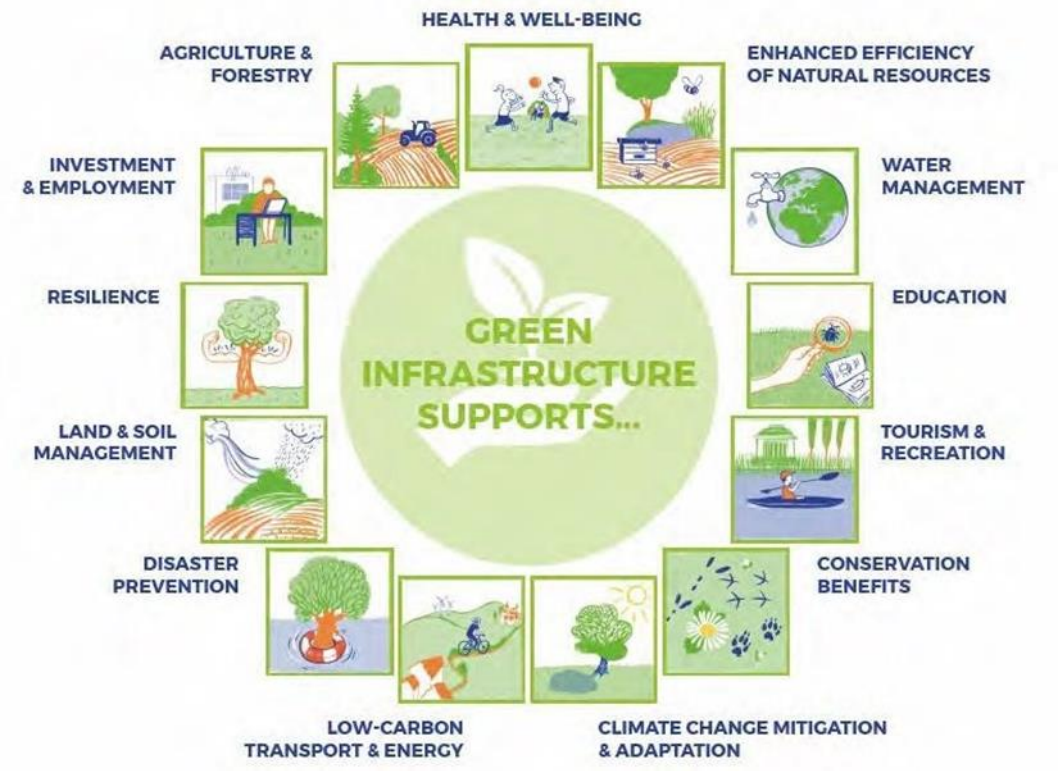
Cultural services include the non-material benefits that contribute to cultural development and practices, e.g. through recreation, spiritual enrichment, cultural meanings, cognitive development, and reflection. For example, they include the opportunities offered by ecosystems for leisure activities, 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

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[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])

3 An integrated approach to green infrastructure

Despite the increasingly recognised benefits of green infrastructure (GI), the consideration and uptake of GI remains limited. The main challenges to mainstream the implementation of GI are related to the institutional, regulatory, and financing framework in place, as well as the existing technical capacity. This chapter identifies and discusses some of these challenges and trade-offs for GI planning and development in OECD countries. It brings together insights, good practices, and a discussion on the lessons learned from the perspective of public governance, environment and transport policies and planning. The chapter considers a life-cycle perspective to propose an integrated approach to GI. It first looks at the institutional and regulatory framework needed to enable GI, to then identify the main elements necessary to promote GI during the planning, appraisal, financing, procurement, and maintenance of infrastructure assets.

Leveraging on lessons learned and international good practices, the OECD has developed an integrated approach to GI which considers the entire life cycle of infrastructure projects and builds on six main pillars. The proposed approach considers all the main trade-offs and challenges involved in GI planning and nature-based solutions (NbS) implementation, and highlights the opportunities to integrate these two instruments in the planning and design, implementation, procurement and delivery, monitoring and maintenance of infrastructure investments.

3.1. Establishing a sound institutional framework for GI

Despite the recognised benefits of GI, governance arrangements are often ill-suited for their planning and implementation. As GI cut across sectoral boundaries, geographical areas, and jurisdictions, GI usually require the **engagement and collaboration of a diverse policy and practitioner community** (Bisello et al., 2019[1]). For example, the creation of green spaces to reduce flooding might require the co-operation of spatial planning agencies and private actors, as well as housing, environment, and water management authorities across levels of government. However, national and local stakeholders tend to work in silos, with limited collaboration and co-ordination across sectoral agencies and levels of government (Nature Squared, 2021[2]).

For this reason, it is **critical to set up an institutional framework that encourages co-ordination**, co-operation, and knowledge exchange across agencies, sectors, and levels of government. In order to enhance co-ordination, it is also critical that the existing regulatory frameworks for GI are harmonised across and within countries. At the same time, a **clear definition of mandates, roles, and responsibilities for the GI planning, implementation, and maintenance** has the potential to accelerate the uptake of GI at all levels of government (OECD, 2020[3]). These key elements to be considered when designing the institutional framework for GI are summarised in the Table 3.1 below.

Table 3.1. Checklist for setting an institutional and regulatory framework for GI

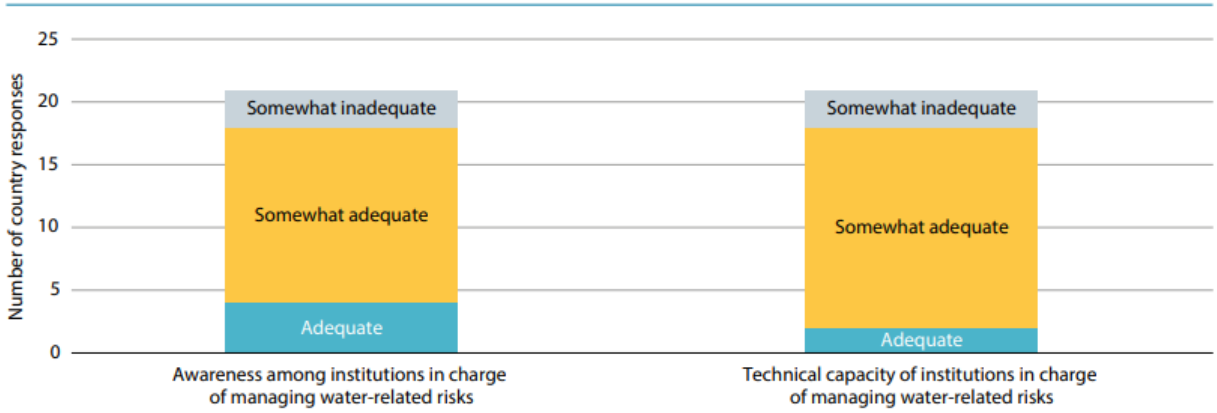
Key institutional arrangements to be evaluated	Key policy elements to be evaluated
Responsibilities for the different phases of GI: planning, implementation, and maintenance	Clear mandate and political support for GI
Co-ordination mechanisms (horizontal and vertical)	Coherence between sectoral policies, and mechanisms to address trade-offs
Partnerships and information sharing	Setting a common narrative and specific guidelines on GI
Integration of GI training in civil engineering and urban planning curricula	Methodologies in place for measuring benefits
Training and education	Inventory of existing natural capital/assets

Source: based on (OECD, 2020[3])

In order to effectively manage GI, the **knowledge base and capacity** of all the stakeholders involved is also critical. Yet, the lack of such capacity is often a key challenge to the planning, implementation, and maintenance of green infrastructures. This was demonstrated by a recent OECD survey, which found that the availability of technical capacity for the design, implementation, and monitoring of green infrastructures as well as the limited awareness of the benefits of ecosystem services and the potential solutions offered by GI within public agencies were major obstacles to GI planning and development (Figure 3.1). The lack of **specific guidance on the planning, implementation, and maintenance of GI** further exacerbates these challenges (Bisello et al., 2019[1]) and makes GI interventions easier to consider in larger cities, which usually have a larger pool of experts and resources to tap into. Consequently, while a growing number of individual GI initiatives exists, these tend to be concentrated in major urban areas, leaving behind smaller urban centres and rural areas. Besides, due to limited capacity, these interventions are often disconnected from other existing GI (Trémolet S. et al., 2019[4]; OECD, 2020[3]), failing to link to

existing ecological networks and to enhance landscape connectivity (Bisello et al., 2019[1]; OECD, 2021[5]). To help raise awareness and build capacity, some OECD countries have started creating toolboxes and guidance books compiling best practices and performance data to support policy makers and GI practitioners in the implementation of GI (OECD, 2021[5]). The United Kingdom compiled over 60 case studies highlighting best practices related to a climate risk: natural flood management. The EU has developed some platforms to support climate adaptation and GI planning, such as ClimateADAPT and Urban Nature Atlas. In order to support decision making phases, the EU-funded UNaLab developed an NbS technical handbook to guide stakeholders in the selection of NbS most adapted to specific contexts (OECD, 2021[6]).

Figure 3.1. Awareness and capacity level for GI across OECD countries



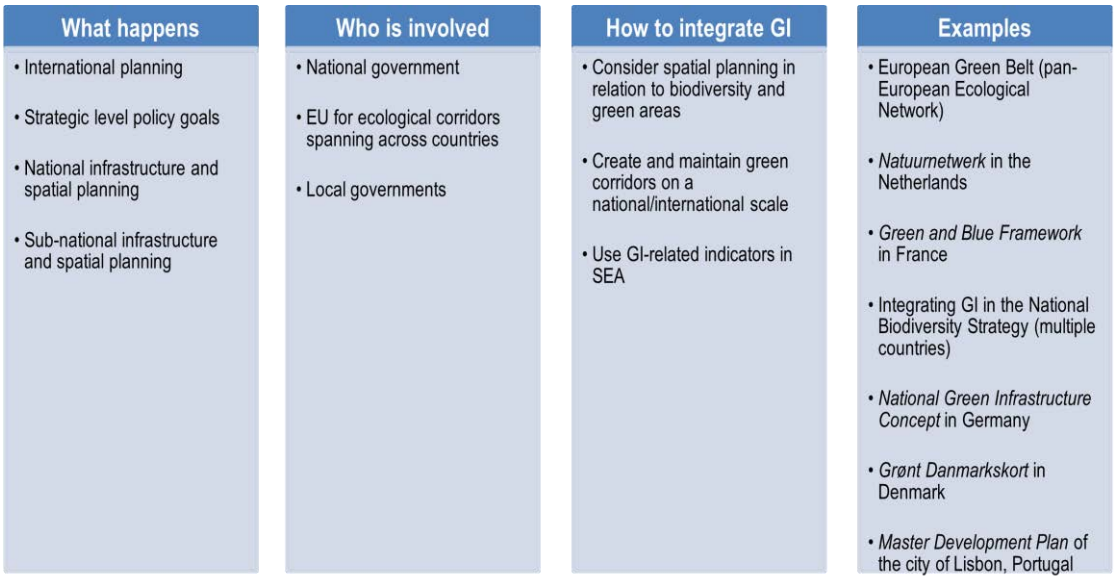
Note: Response to the question: "How adequate are the following features in relation to eco-system-based approaches to water management in your country/basin?"'; multiple responses were possible; no respondents selected "inadequate".
Source: (OECD, 2020[3])

3.2. Planning and developing GI

The planning and implementation of GI largely depends on the policy and regulatory environment of each country and jurisdiction. Indeed, through their plans, strategies, and policies, governments can promote or hamper the development of GI. For example, regulatory and planning instruments at both the national and sub-national level can encourage the consideration of GI in landscape and urban planning processes. For example, strategic environmental assessments (SEA) can recommend or require the integration of GI before individual policies are designed and approved.

The infrastructure planning phase typically involves national governments and sectoral infrastructure agencies. For GI spanning across multiple countries, international bodies, such as the European Union, can also be involved. Sub-national governments are also usually involved, due to their critical role in spatial planning. For example, through their Sustainable Urban Mobility Plan (SUMP), municipalities can promote and plan GI (see Section *Green Infrastructure in Transport Planning in Italy* above). Overall, in order to plan effective green infrastructures, it is critical that spatial planning at all levels of government pays due attention to ecological connectivity across natural areas. In practical terms, this means creating and maintaining green corridors to allow for species mobility and ecosystem services, regardless of national or sub-national boundaries. Figure 3.2 shows a summary of what infrastructure planning encompasses.

Figure 3.2. Overview of infrastructure planning



In some cases, the consideration and planning of GI can be challenging due to the intrinsic characteristics of GI. For example, since GI often requires large spaces to fully deliver its benefits, its consideration in the planning of infrastructure projects might be difficult. This can be particularly problematic in urban areas, where the high demand for land increases the opportunity cost of some types of GI interventions (Nature Squared, 2021[2]; OECD, 2021[6]). Besides, some types of green infrastructures require the active support and participation of citizens and other local stakeholders, such as land and building owners, throughout the planning, implementation, and maintenance process (Frantzeskaki and McPhearson, 2022[7]). This engagement is often gradually built over time through iterative processes that can be perceived as lengthy and costly by local and national administrations (Bisello et al., 2019[1]; OECD, 2021[6]).

Despite these challenges, GI is gaining a growing attention at the international level, and a growing number of good practices and examples of effective GI planning and implementation is being developed. For example, the **pan-European Ecological Network** (PEEN) aims to identify, protect, and ensure the connectivity across core ecosystems and natural areas across several European countries, with the goal of implementing the tenets of the Convention of Biological Diversity throughout the European territory. This pan-European initiative links to many national ones. For instance, in the **Netherlands**, a national network of nature areas and water bodies (the *Natuurnetwerk*) has been developed with the goal of enhancing ecosystem connectivity in the context of the PEEN. The national government and the regions share the responsibility for maintaining and ensuring the connectivity among these areas. The network is included in national spatial planning policies, such as the Structure Vision Infrastructure and Space. Another example of successful planning and development of GI is **France**'s *Green and Blue Framework*, i.e. a national green development strategy that aims to preserve biodiversity, protect the natural landscape, contribute to water management, eventually supporting adaptation to climate change. As for the *Natuurnetwerk* in the Netherlands, the *Green and Blue Framework* needs to be considered in land use and landscape planning throughout the country (Office Français de la Biodiversité, 2022[8]). Several plans and strategies, such as for example the 2030 National Biodiversity Strategy (Gouvernement, 2023[9]), are in place to support the implementation of the Framework at the national, regional, and local level.

Similarly to France, several other **EU countries mention GI in their National Biodiversity Strategies**. These include for example Austria, Belgium, Finland, Germany, Greece, Hungary, Luxembourg, Malta, and Spain. For instance, Austria's National Biodiversity Strategy includes targets on integrating biodiversity and ecosystem services in spatial planning, with a focus on the importance of integrating ecological networks in spatial and landscape planning. In Hungary and Luxembourg, the National Biodiversity

Strategies pay particular attention to the role of GI for climate change adaptation and ecosystem service provision and maintenance. Germany is the only country in the European Union with a *National Green Infrastructure Concept*, i.e. a document that aims at integrating biodiversity and ecosystem services in territorial development policy. The document is also linked to the country's National Biodiversity Strategy.

Denmark's experience with the "*Green Map of Denmark*" (*Grønt Danmarkskort*) is also particularly relevant. The country introduced this tool in its national Spatial Planning Act in 2015, with the aim to ensure that ecologically relevant ecosystems in Denmark were sufficiently interconnected to allow species to move and thrive. Overall, this Green Map sets out a strategic policy framework to ensure that existing and new natural areas throughout the country are located in a strategic way that has the highest impact on ecosystem health and connectivity. The tool also supports land-use planning processes and the planning of new GI by providing a concrete map of existing green areas throughout the country. According to the Danish Spatial Planning Act, municipalities have the responsibility to designate areas to the Green Map based on a common base map and a common set of criteria. Since 2017, Danish municipalities are also required to include GI and relevant natural areas in their municipal plans (Biodiversity Information Systme for Europe, n.d.[10]).

A growing number of good practices in GI planning and implementation is also emerging from sub-national administrations, which are critical to promote GI in spatial planning. For example, the Master Development Plan of the municipal administration of Lisbon (**Portugal**) considers the ecological network as a key element for city planning. The document includes a series of interventions to strengthen the continuity and complementarity of natural and semi-natural systems in the urban territory, which is strongly constrained by the dense urban fabric. Building on this plan, between 2009 and 2017, the local government has developed approximately 190 ha of new green areas as well as six green corridors for better ecosystem connectivity. The resulting benefits include wider accessibility to urban and peri-urban green spaces for residents and tourists, as well as positive impacts on health by promoting active transport modes (walking/cycling), environmental impact gains and additional income (and jobs) from an increased number of visitors (Architects' Council of Europe, n.d.[11]; Biodiversity Information System for Europe, n.d.[12]; OECD, Forthcoming[13]).

3.3. Financing GI

Today, green infrastructures are mostly financed through public budgets and philanthropic initiatives (Ozment, Ellison and Jongman, n.d.[14]). According to the UNEP, current global investments for green infrastructure are around USD 133 billion[1] every year[2] (UNEP, 2021[15]). Of these, USD 115 billion (i.e. approximately 84%) come from public resources, mainly in the form of government spending for the protection and restoration of biodiversity and landscapes and through specific government projects on sustainable forestry, agriculture, and fisheries. In addition, an average USD 18 billion come from private sources, mostly in the form of investments in sustainable supply chains and environmental offsets. While considerable, these channels alone are often insufficient to support the effective implementation of green areas at the landscape level (Ozment, Ellison and Jongman, n.d.[14]). Indeed, to meet existing international policy targets and effectively address the climate crisis, land degradation and biodiversity loss, global investments in ecosystem conservation would need to almost triple by 2030 and to reach at least USD 536 billion per year by 2050[3] – i.e. at least four times the amount invested today. At the global scale, this corresponds to a financing gap of about USD 403 billion per year (UNEP, 2021[15]).

The financing of GI initiatives that promote ecosystem preservation and restoration often meets a number of challenges (Trémolet S. et al., 2019[4]; OECD, 2021[6]). First of all, ecosystems and their services represent a public good whose many co-benefits are usually not traded in the market. For this reason, the economic benefits associated to their conservation, as well as the costs associated to their degradation or loss, are often not adequately valued, or considered, in policy and economic decisions. This challenge is

further exacerbated by the fact that GI provide diffuse benefits and co-benefits on a large geographic scale, often leading to a mismatch between the stakeholders who pay for ecosystem and biodiversity conservation and the broader communities that benefit from their preservation (Rendlen and David, 2021[16]), and thus making it difficult to reward those who contribute to the financing of GI (OECD, 2021[6]). Besides, green infrastructures are dynamic systems that provide benefits and returns over long timeframes, which can discourage private investors and administrations that seek for short- or medium-term economic and political returns and service levels (Nature Squared, 2021[2]; OECD, 2021[5]). All these factors combined tend to discourage the consideration and integration of GI initiatives.

Yet, as highlighted by the Nature-based Solutions Global Resource Centre[4], there exist a variety of fiscal interventions, market and regulatory instruments, and other hybrid mechanisms that can be used to finance GI at the government level and to crowd in further GI financing from private stakeholders (Rendlen and David, 2021[16]). When effectively combined, these instruments and interventions can make GI more attractive for potential financiers (OECD, 2021[6]).

- ***Tax Increment Financing*** can be used to finance GI and broader ecosystem regeneration projects based on anticipated future tax revenues resulting from GI development. When a Tax Increment Financing district is established, the "base" amount of property tax revenue is recorded using the status quo before improvements. For example, a new public green space prompts a rise in property values, leading to an increase in actual property tax receipts above the base. While the base amount of property tax revenue continues to fund the maintenance of GI, the additional tax revenue can be used to pay bonds and reimburse investors.
- ***Blended public funds*** providing capital in the forms of grants, equity or debt consist in funds from the budgets of several public entities that are pooled and used to fund or de-risk investments in nature and biodiversity as part of a blended finance scheme. This mechanism provides a source of risk capital that can leverage other sources of financing, with the additional benefit that the funding comes from existing budgets.
- ***Debt-for-nature*** represent an opportunity for raising financing to address biodiversity, ecosystem, and climate challenges. Under these schemes, a creditor government or business swaps repayment against the debtor's commitment to fund local conservation projects. NGOs or donors can also purchase a debt and then swap it against the debtor's commitment to fund specific GI.
- ***Carbon tax*** levied on activities that are harmful to nature can also largely contribute to GI initiatives through the tax revenues, which can be earmarked to fund nature conservation measures.
- ***Betterment levies*** consist in a tax or fee levied on those lands that gain value following a GI intervention. Under this scheme, the stakeholders that benefit from GI, such as land or property owners benefitting from higher revenues or higher property valuations, can be subject to an additional tax whose revenues can be used to maintain the GI that generates this value increase. Betterment levies can also be used to fund non-revenue-generating green infrastructures.
- ***Business improvement districts*** consist in contracts stipulated between municipal governments and private capital holders, under which the latter must contribute towards the rehabilitation of natural areas or ecosystems. Once a given level of regeneration is achieved, the 'district', comprising public and private counterparts can then take responsibility to manage and maintain the GI.
- ***Trading of storm water credits*** are schemes for the trading of credits to manage storm water and the pollution of natural waterways from storm water discharge. The revenues generated through credit sales are then used to establish a secondary market to attract private investment for larger storm water management initiatives. In other words, this mechanism creates a monetary value for stormwater management, which incentivises property developers to explore GI potential to address water management issues.

- ***Resilience bonds*** are bonds issued to finance climate-resilient upgrades that are paid back through subsequent cost savings, which can result from example from lower insurance premiums. In other words, this instrument aims to shift financing from post-disaster relief to pre-disaster preparedness and prevention. By transferring disaster risk from governments to insurers, resilience bonds allow to raise financing for GI that could otherwise not be realised. This instrument is, however, still in the pilot stage.
- ***Payment for ecosystem services (PES)*** are instruments that incentivise and compensate stakeholders for developing or maintaining GI. Under PES schemes, beneficiaries are encouraged undertake restoration and conservation actions that benefit them as well as the broader community. PES can be used as revenue streams from GI and ecosystems that would otherwise not generate any income.
- ***User fees*** are fees levies on the users of natural capital in exchange of the ecosystem services they benefit from. This could encompass, for example, entrance fees paid by those who visit national parks.
- ***Transfer arrangements*** are schemes that involve the transfer of natural assets to community organisations at less than market value, requiring in exchange the management, conservation, or regeneration of those lands and ecosystems.

3.4. Promoting the use of nature-based solutions in project planning, prioritisation and appraisal

Project design, prioritisation and appraisal offer an excellent opportunity to assess and promote the benefits of Nature-based Solutions. In this project phase, further project-level planning, evaluation, and design take place, e.g. planning a specific link or segment of a transport network. Moreover, the inclusion of GI and NbS considerations from the project preparation phase would also facilitate the access to climate-based and blended financing.

Integrating NbS in project design would also require engaging all relevant stakeholders, including citizens and local communities, since the beginning of the project. The early engagement of local communities would contribute to create a sense of ownership and responsibility with respect to the infrastructure projects under scrutiny, and it will also help them better understand all the challenges and trade-offs that need to be considered when integrating NbS. Despite some additional costs and efforts in the design and evaluation phase, the early engagement of local stakeholders will pay back at the implementation and maintenance, avoiding delays, additional costs and inefficiencies.

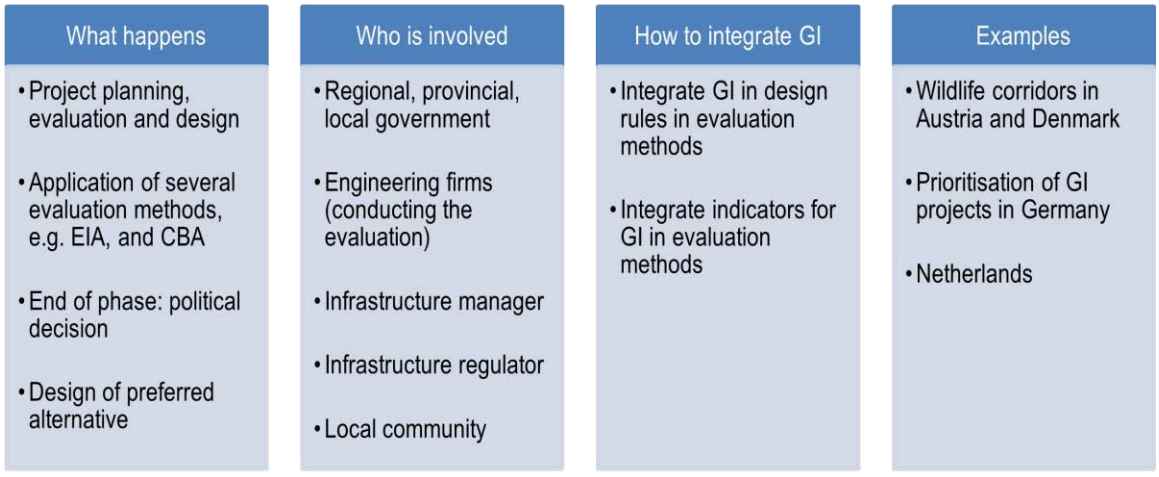
The project evaluation uses many assessment procedures and methods, the most common ones being EIA and CBA, as are also applied in Italy. This phase ends with the political decision for a specific project option. There are usually multiple stakeholders involved in this phase, depending on the nature of the project. Stakeholders come from the public (e.g. relevant governments, regulators) and private sector (e.g. engineering companies, firms conducting the evaluations, and infrastructure managers). Moreover, public consultation is typically part of this phase. An overview of the elements of project planning, prioritisation and appraisal is outlined in Figure 3.3.

In addition to their primary purpose, NbS can generate ancillary social, economic and environmental co-benefits related to human health and livelihoods, food and energy security, ecosystem rehabilitation and maintenance, climate adaptation and resilience, and biodiversity (Browder et al., 2019[17]). While the benefits of traditional grey infrastructures are immediately visible, green infrastructures and infrastructures with NbS generally take a longer timeframe to fully materialise their benefits (Kabisch et al., 2016[18]; OECD, 2020[3]). These co-benefits of both GI and NbS are often not reflected in traditional assessments carried out at the appraisal stage of infrastructure decisions and investments. The existing methods for

assessing, valuing, and monitoring these co-benefits are often underdeveloped or challenging to apply (Trémolet S. et al., 2019[4]). Moreover, there exist a wide variation in the type of ecosystem services NbS support, and the specific costs and benefits of different infrastructure solutions are dependent on local circumstances (Brown and Mijic, 2019[19]) . Finally, there can be trade-offs between different ecosystem services. For example, enhancing the recreational capacity of a park may lead to pressures on its biodiversity through more intense use and associated disturbances.

Nonetheless, there are ways to encourage the consideration of NbS versus traditional grey solutions, using a combination of traditional appraisal tools and non-traditional methods that allow for more inclusive reporting on indicators that grasp the benefits of NbS. This can even be applied within the existing procedure of EIA. In addition, this can also be integrated into the CBA methodology for the assessment and comparison of project alternatives but complementing them with, for example, multi-criteria analysis (MCA), which allows for comparing project alternatives on their scores on both quantitative and qualitative criteria. It, therefore, allows for a fairer comparison with projects that do not necessarily score high on monetary outcomes but do have benefits to nature and social indicators.

Figure 3.3. Overview of project prioritisation and appraisal phase



One example where NbS are integrated in **project planning** is the “Infranature” programme in the Netherlands. This programme is a so-called “Green Deal", which is an agreement between the State and other stakeholders, where the State commits to update legislation and regulation, act as a mediator or develop new markets. Green Deals are thus focused on co-operation and are not a financing instrument. The Infranature programme supports infrastructure that integrates and supports biodiversity. Up until today, twenty-three infrastructure stakeholders have joined the initiative and have thus promised to ensure an increase in the attention to biodiversity in the construction, management and maintenance of infrastructure (i.e. highways, railways, waterways)[5]. Examples of projects within the programme are sound walls with integrated greenery next to a highway or insect-friendly maintenance of roadsides (InfraNatur, 2019[20]).

Another option for the promotion of NbS in project planning is by defining specific rules for biodiversity conservation for certain types of projects. In Austria, this type of rule is applied in the planning of roads and railways[6]. If these infrastructures cross nature areas and create a barrier for wildlife, it is mandatory to establish a wildlife corridor, such as an eco-bridge or tunnel every three kilometres at a minimum. The width of the wildlife crossing must be at least 25 to 80 metres, depending on the situation. This inclusion must already be present in the project design, and it is assessed in the EIA procedure. Newly built roads and railways must comply with these conditions, and existing infrastructures are also being updated to comply with the rules[7]. Denmark has a similar mechanism to ensure safe wildlife crossings; the risk of

fragmentation of habitats and ecosystem is assessed in the EIA and corrective solutions are then integrated in projects' design and implementation.

There are also multiple solutions to promote the use of NbS in the prioritisation and appraisal of infrastructure projects. Countries can integrate NbS in the appraisal process by assessing and factoring in the impacts of infrastructure projects on biodiversity. Most notably, in 2009, The Netherlands developed the biodiversity points method, which measures the amount and quality of ecosystem services and biodiversity and their changes (i.e. the project's impact) in a standardised way. Its use is recommended in the national guidance on CBA. The biodiversity points are calculated by multiplying three components: (i) the area of natural and semi-natural ecosystems affected (in hectares or square km); (ii) the ecological quality of each area; (iii) a weight factor per type of ecosystem, which reflect the contribution of the ecosystem to the species richness at the national, European or global level. The weight factor varies according to the species population the ecosystem and their threat level (Bos and Ruijs, February 2019[21]).

Another way to promote the integration of NbS in the prioritisation and appraisal of infrastructure projects is by developing indicators, and eventually targets specific for NbS. For each project, it should be made clear how it contributes or affect such indicators or targets. For example, the European Environment Agency (EEA) proposes indicators to measure and consider the share of green areas in cities or the distribution of green urban areas for urban infrastructure projects[8]. Non-urban indicators can be related to biodiversity, fragmentation, and buffer zones. Another example related to the use of indicators and targets is the Interreg Danube Programme, which has developed a training package on using EIA for integrated GI planning[9]. According to this training package, a multi-criteria analysis (MCA) should be used to differentiate between project alternatives. The criteria to include should be measurable and preferably economically representative. They should consist of habitat loss, habitat fragmentation/permeability and disturbance, and criteria related to the individual projects, such as their influence on critical habitats. Moreover, the selected option is bound to three constraints: 1) the lowest degree of habitat loss; 2) avoiding intersections of natural protected areas; 3) avoiding intersections of ecological corridors.

3.5. Procurement and delivery of NbS

In order to promote the implementation of nature-based solutions, public administrations can leverage their purchasing power. As of today, public procurement accounts for 12% of GDP across OECD countries, testifying that the public sector's demand cover a relatively large market share. In addition to that, public authorities can lead by example, encouraging other administrations, businesses and citizens to invest in and implement NbS.

To date, public procurement of NbS is still limited. This is probably due to the relatively novelty of NbS concepts in mainstream planning practices, which implies public administrations might not yet be familiar with the purchase of these particular "products/services". Moreover, there are other challenges public procurers are likely to face, and these are summarised in a recent report published by the European Commission (2020[22]).

As mentioned in the previous section, there is no widespread consensus on the most effective tools and methodologies to measure and quantify natural assets' performance, including associated costs and benefits. Likewise, the strong diversity of needs and technologies for NbS implementation makes it challenging to develop a systemic classification. This feeds public procurer's uncertainty about what specific work/service/product to purchase and the results it can achieve.

Public buyers also have difficulties in finding contractors with the adequate experience and skills to deliver NbS. In addition to that, public tenders for NbS tend to have low contract values. The combination of a low contract value with high technical requirements struggle to attract significant interest from the market. This

results in low numbers of bid submitted and reduced competition, which has negative affects the quality of the offer.

In addition to economic and environmental impacts, NbS offer social benefits, such as enhanced quality of life, increased access to public green spaces, new opportunities for social interaction among community members, recreational, cultural and educational value, enhanced physical and mental well-being of people, and so on. In many cases, the involvement of the local community is key to ensure NbS are designed and procured effectively to meet the needs of the area, as well as to ensure their adequate maintenance over time. However, many communities have had negative experiences in engaging with public authorities, and there is an impression that the local community's views and needs are often ignored and not acted upon. This has often resulted in a lack of trust towards public authorities, which leads to consultation fatigue and little to no engagement by citizens in NbS.

Finally, and as public procurers use taxpayers' money, they tend to adopt a risk-adverse approach and prefer predictable and familiar processes and solutions. This results in the procurement of conventional "grey" solutions. In other words, the limited track record of NbS so far, and the "high-risks" and "high-costs" that are traditionally associated to green solutions feed the reputational concerns of public buyers.

The report by the European Commission also identifies some key tools and strategies for governments and public buyers to facilitate the procurement of NbS. These include (Mačiulytė and Durieux, 2020[23]):

- **Development of Key Performance Indicators (KPIs)**. KPIs to measure and quantify the environmental, social and economic performance of NbS would help practitioners to grasp the holistic value of solutions based on natural assets.
- **"Brokers of NbS"**. Public administrations need to identify innovation brokers, specialised in nature-based projects and solutions. These brokers can promote the procurement of NbS by advocating their value, promoting knowledge transfer and dissemination, helping to break barriers to procurement of such solutions in specific contracting authorities and/or public administrations.
- **Create centres of excellence on procurement of NbS**. Establishing national, regional, or local centres of excellence for procurement of NbS to gather and disseminate best practice examples, develop guidelines and handbooks for implementation, provide training and capacity building, offer ad-hoc technical assistance, and so on.
- **Provide policy support to procurement of NbS.** By developing and adopting a set of policies and a regulatory framework that explicitly support public procurement of nature-based solutions, the government strengthen the incentives for public buyers to incorporate them in their purchases. Considering the difficulties faced to demonstrate the financial case for procurement of NbS, policy support from the top government or higher administrations is pivotal.
- **Promote cross-departmental exchange**. Procurement of NbS needs interdisciplinary skills and knowledge (i.e. law, ecology, economy, natural sciences, engineering, etc.). For this reason, it is important to overcome the silos modus operandi that characterizes the public administration and encourage the interaction of the actors relevant for the successful implementation of NbS. This can be done with the creation of multidisciplinary teams, the establishment of cross-departmental units, or organizing exchange occasions, such as workshops and informal events.
- **Adopt challenges-based thinking in calls for tenders**. Given the wide range of needs NbS can address and the many technical solutions available for their implementation, public procurers often find it difficult to draft clear technical specifications. The suggestion is to focus more on specifying the desired outcomes and let suppliers free to develop innovative solutions to achieve them. Such objectives can be specified in the award criteria. Moreover, taking into account the novelty and complexity of NbS, public administrations should opt for innovative procurement procedures (e.g. the innovation partnership, competitive dialogue, and competitive procedure with negotiation) which allow to have a dialogue with private businesses to develop an effective and high-quality solution. Even though up-front costs might increase for public administrations, in the long-run, NbS

are likely to save money. Preliminary market consultation is also key to gauge market capacity to design and provide products and services that build on natural elements, as well as to develop effective public tenders.

- **Joint procurement**. As public procurers face difficulties in finding suppliers due to low contract value, a solution could be to group together several small contracts for NbS in a single call for tender or establish framework agreement with a pool of suppliers. Also, joint procurement among different contracting authorities can increase the tender value and provide a higher incentive for suppliers to participate.
- **Joint NbS network**. As of currently, different public administrations are implementing projects that leverage natural assets and green solutions. Joining platforms where peers meet, and exchange ideas and lessons learned can help public buyers to overcome the procurement challenges they face.
- **Engage the community**. Considering the high potential of NbS to deliver social outcomes and the key role local communities can have for their effective implementation and maintenance, public administrations need to engage with them. Pilot projects that can showcase the benefits of NbS and give proof that the people's feedback is valued and acted upon can help gain their trust and increase the community's willingness to engage in the design, implementation and maintenance of nature-based products, goods, and services.

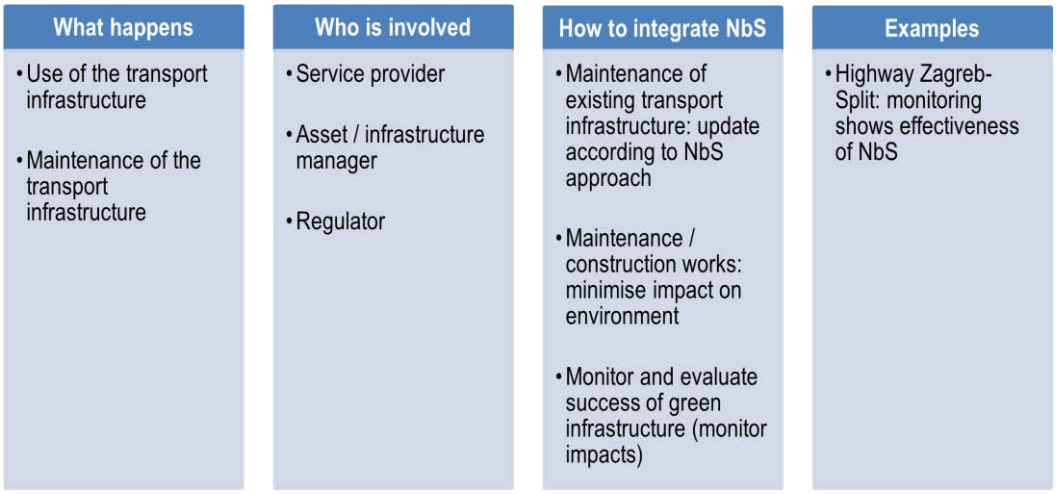
Even though public procurement is an important instrument public administrations can leverage to promote NbS, publicly-led initiatives need to be complemented with alternative delivery mechanisms. Successful public procurement of nature-based solutions in infrastructure projects is useful to create visibility and interest in the topic, but other tools that can increase an incentive also for other social and economic actors to act are necessary. These will help to effectively achieve a widespread implementation of NbS in public investment projects, therefore delivering their full potentials and benefits (European Commission, 2020[22]).

3.6. Monitoring and integrating NbS across the infrastructure lifecycle

Monitoring and maintenance of infrastructures are key to safeguard the function they had planned to fulfil. These actions should be performed throughout their entire lifecycle and include both use and upkeep. This is even more important for infrastructure projects that build on natural assets and integrate nature-based solutions. Natural components and natural processes are complex and dynamic, and they are also more sensitive to a wide range of factors, including changing climate conditions, the surrounding environment, quantity of users, frequency, and modality of use, etc. For this reason, it is necessary to constantly monitor infrastructure projects that include NbS to assess their status and level of performance and intervene as needed.

Regarding monitoring, performance indicators should encompass both the use and maintenance phase of infrastructure projects. Particular attention should be paid to assess the performance on biodiversity and ecosystem services criteria to assess the effectiveness of NbS in delivering the expected objectives. Results from monitoring should then be used to inform the management of the infrastructure, including changes in the modalities of use and effective maintenance. Government is usually less involved in this phase, and responsibilities are delegated to service providers and infrastructure managers. However, a regulator is typically involved in reviewing their performance and monitoring the infrastructure's functionality. Some infrastructure projects and programmes even have their own monitoring committee. An overview of this phase is outlined in Figure 3.4.

Figure 3.4. Overview of infrastructure monitoring and maintenance



Monitoring and maintenance help ensure infrastructure projects stay in good shape after realisation, ensuring they fully deliver the expected results. It is important to start monitoring early. For example, start at least in the appraisal phase by setting out indicators for monitoring the infrastructure during its lifetime. The monitoring and maintenance phase can also be adapted for existing infrastructure assets to keep track and improve their impacts on ecological connectivity by integrating NbS.

An example of monitoring the effectiveness of NbS in infrastructure projects is the highway between Zagreb and Split in Croatia. This highway was built with multiple tunnels, green bridges, and underpasses for wildlife. One of the objectives was to reduce habitat fragmentation and enable wildlife to cross the highway into other natural areas. Monitoring has since shown that wild animals do use these different facilities. However, green bridges are more effective than underpasses, especially for larger wild animals[10].

Monitoring can also be used to intervene on existing infrastructure assets and networks, and integrate NbS to improve their performance, extend their lifespan, and make them more resilient to changing climate conditions and extreme weather events. The Alps-Carpathians corridor is an EDRF-funded initiative[11] to restore biodiversity and wildlife in the Alps-Carpathians region around the border of Austria and Slovakia. The region, historically a migration route for wildlife, was fragmented as a result of economic development, and transport infrastructure broke up habitats. Several roads have since been upgraded to include green bridges for wildlife passage.

Regarding maintenance, this is key to ensure continuity of service and the high-quality performance of every type of infrastructure, especially NbS. The maintenance of NbS may require the active support of local communities and citizens, for example through tasks such as replanting trees or maintaining water retention structure. For this reason, engagement of key stakeholders should be undertaken from the very early stages of infrastructure investments, for example in the design phase. This will help feeding a sense of ownership and responsibility, therefore ensuring stakeholders' active participation in maintenance activities. In 2019, the city of Turin decided to procure green walls for two public buildings, and maintenance required the participation of the local community. The community engagement started at the very beginning with local inhabitants selecting the two buildings for the project. The city considered several schools and public buildings and engaged with their occupants. The purpose was to find occupants who were truly interested in the project, would benefit from it, and were motivated to take part in maintenance duties in the long run. The selected buildings were a public school where teachers, where keen on using green walls and maintenance activities as an educational tool for students, and a homeless shelter, where maintenance of green walls could provide residents with contact to nature and opportunities to learn new skills. Thanks to the community engagement in maintenance activities, the city of Turin also saved money (European Commission, 2020[22]).

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Notes

[1] Estimates are taken from the report "State of Finance for Nature Tripling investments in GI solutions by 2030", published by UNEP in 2021. As specified in the original text, these estimates are uncertain because capital flows into GI are not tracked or reported consistently. The methodology – which is described in the Annex to the report - employs data sets on public and private expenditure relevant to GI. However, none of the existing data sets label GI transactions explicitly. Moreover, only a small subset covers the universe of relevant transactions that are internationally comparable. Hence, the methodology relies upon assumptions to separate out the GI component of capital expenditure. The quality of the data varies widely across sectors and geographies, so the uncertainty of estimates varies to reflect this (UNEP, 2021[15]).

[2] The report of reference uses the global standard developed by the International Union for the Conservation of Nature (IUCN) for green infrastructures. Accordingly, GI is defined as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits*". The following preliminary principles are to be considered with this GI definition: (i) GI embrace nature conservation norms (and principles); (ii) GI can be implemented alone or in an integrated manner with other solutions to societal challenges (such as technological and engineering solutions); (iii) GI are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge; (iv) GI maintain biological and cultural diversity and the ability of ecosystems to evolve over time; (v) GI are applied at a landscape scale; (vi) GI recognize and address the trade-offs between the production of a few immediate economic benefits for development and future options for the production of the full range of ecosystem services (UNEP, 2021[15]).

[3] These estimates are based on an immediate action scenario, in which the global community is assumed to act now to halt climate change at 2 degrees; reverse loss and stabilize biodiversity intactness by 2050 at today's levels; and stop land degradation. Decisive action begins in 2020 in this scenario. Immediate Action Scenario has been developed by Vivid Economics for the UK's Treasury Under the Dasgupta Review. It depicts a future in which the world acts immediately to combat climate change and halt biodiversity depletion. The Annex to the UNEP Report provides a full description of the underlying assumptions (UNEP, 2021[15]).

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4 The state of play for green infrastructure and nature-based solutions in Italy

Despite recent efforts to improve the environmental performance of public investments in Italy, more needs to be done for the country to ensure a widespread adoption of green infrastructure (GI) planning across the national territory. This chapter provides a detailed overview of how GI and nature-based solutions (NbS) are currently implemented in Italy. It outlines the main policies, strategies, laws, and planning instruments relevant for GI and NbS and identifies the main actors responsible for infrastructure planning and implementation. At the project-level, the chapter looks at the different tools in place to integrate environmental considerations in infrastructure planning and appraisal, as well as in the financing and delivery of public investment projects. The chapter includes the analysis of four case studies in Italy, which highlight good practices and main areas for improvement to mainstream GI and NbS implementation.

GI and NbS are relatively new concepts in the infrastructure field and their transversal nature cuts across geographic areas, sectors, jurisdictions, involving a multitude of actors with different roles and responsibilities. In Italy, GI planning and NbS implementation involves all levels of government as defined by Article 117 of the Italian Constitution, potentially causing some hurdles in their implementation. At the central level, the main administrations involved are the Ministry of Infrastructure and Transport (MIT) and the Ministry of Environment and Energy Security (MASE). They tend to have different roles and responsibilities, but sometimes these might overlap. At the sub-national level, the administrations involved are regions and municipalities, provinces and metropolitan cities, according to the specific functions assigned to them by the normative and regulatory frameworks.

In the absence of a central-level policy and regulatory plan governing GI and NbS, some isolated good practices have been developed at the subnational level (see Box 4.1). However, the existing framework and tools must be strengthened in order to ensure a more widespread and consistent adoption of GI and NbS across the whole national territory.

Box 4.1. Examples of GI and NbS in Italy - selected by the OECD

NbS to reduce landslide risk in Nocera Inferiore (Campania)

The project was implemented in 2018-2019, after a three year-long public participatory process. Local citizens and residents were given the opportunity to co-design the NbS, together with government officials, researchers, experts, and other stakeholders.

The final aim of the project was to limit/reduce landslide risk at the foot of Monte Albino. The implemented NbS included the maintenance and restoration of the mountain slope, channel lining, and vegetated and stone gabions aimed at reducing erosion due to frequent rainfall events. These solutions were part of a more comprehensive and hybrid plan that included, among others, complementary grey infrastructure, the improvement of walking paths, and improved management of public and private forests.

The preference for a NbS solution prevailed strongly within the local community for three main reasons:

1. Reluctance to adopt grey solutions by interest groups and expert communities: this could be explained by the higher building and maintenance costs associated with grey infrastructure, as well as by their aesthetic and environmental impact.
2. Wide stakeholder engagement: the public participatory process involved local residents in the design of a landslide risk mitigation plan.
3. Limited funding available: the limited disposal of economic resources favoured NbS, as this was seen less costly compared to grey solutions, both for building and maintenance costs.

Additionally, the project provided multiple co-benefits, such as recreational value, equity in protecting the community, aesthetic value, increased access to mountain areas, heightened risk/environmental awareness along with economic benefits.

Vertical Forest in Milan (Lombardy)

The project is part of a larger plan known as “The Porta Nuova project”, which aims at transforming the urban neighbourhood of Porta Nuova into business and residential district rich in green infrastructure.

The Vertical Forest consists of two residential towers that are 110 and 76 m high, hosting 900 trees and over 20 thousand plants (a wide range of shrubs and floral plants) distributed according to the sun exposure of the facade. It is estimated that the ecosystem services from the plants in the two towers (CO_2 storage, air quality, biodiversity improvement) are equal to the services of 2 ha of forest.

An experimental campaign in 2013 demonstrated that the vegetation in the towers was capable of reducing particulate concentration. The percentage of average abatement, due to the plants, ranged from about 30% to 20% for PM10 (Particular Matter) and TSP (Total Suspended Particulate) respectively. These results confirm the effective potential of trees and green barriers (shrubs and hedges) in removing airborne particulate matter. These are common features of urban forests and pocket parks, which improve the urban environment and life quality of local residents and confirm the need to preserve and increase urban vegetation.

GAIA Project in Bologna (Emilia-Romagna)

The GAIA Project is part of the Climate Adaptation Plan of the city of Bologna. It has been managed by the local municipality, and it is co-financed by the European Commission. The project lasted for 3 years – from 2010 to 2013 – and pursued the scope to greening the city with the planting of trees and the creation of new urban green spaces.

GAIA is based on a public-private partnership model to finance tree planting. Most notably, it leverages financial compensation for the carbon footprint of businesses as a main driver for action. The financial compensation is used to purchase plants and maintain trees throughout the city. Moreover, the participation in the GAIA initiative is on a voluntary basis.

A business that is interested in participating in GAIA can request an easy-to-use tool from the project website. This tool allows businesses to calculate the quantity of carbon dioxide involved in their processes and services. Next, the businesses can select the type of partnerships they would like to purchase to neutralise their carbon footprint.

Source: (OECD, Forthcoming[1]; Martin et al., 2021[2]; Oppla, n.d.[3])

4.1. Definition and legislative framework for GI in Italy

In the discussions that took place during the fact-finding Mission[1], it emerged that the main institutions responsible for infrastructure planning and implementation (i.e. MIT, MASE, and sub-national administrations) adopt slightly different definitions for GI, and reduced co-ordination among them is likely to be an obstacle to the development of a shared approach and knowledge-base. Nonetheless, this is not an uncommon phenomenon. GI is a relatively new concept in spatial planning across the world, and international literature also does not provide an unambiguous definition and interpretation.

For the scope of this report, GI is considered as a planning instrument to ensure that the protection of biodiversity and ecosystem services as well as ecological networks are considered, right from the outset, in territorial and infrastructure development. On the other hand, the term “NbS” refers to specific project-level solutions, including the use of natural materials and the integration of mechanisms that mimic nature in infrastructure projects (e.g. integration of green walls or roofs in buildings, or the use of permeable rather than impermeable pavements to ensure water absorption and retention capacities, therefore mitigating the effects of heavy rains).

To date, Italy has defined a series of national regulations and directives on topics related to green infrastructure, such as protected areas, biodiversity protection and ecosystems, and the Natura 2000 sites[2]. Moreover, in compliance with the European framework on Biodiversity Protection, Italian Regions integrate green infrastructure in the definition of their Regional Ecological Networks (i.e. Reti Ecologiche Regionali or REN). In certain Regional Territorial Plans (RTPs), RENs are recognized as priority infrastructures, and they represent a key tool to orient spatial planning at the regional and local level.

In 2013, the country approved the **law 10/2013** on *Norms for the development of green urban spaces*, which is the main national legislation on urban green spaces. This law exclusively focuses on the urban level (e.g. the planting of trees and the creation of green spaces in urban spaces)[3]. Article 3 of Law 10/2013 establishes the creation of the **National Committee for the development of public green spaces** – coordinated by MASE – which has the mandate to monitor the law's implementation and promotes compliance by providing guidance to local administrations. The Committee has defined the **National Strategy on Urban Green Spaces** and a set of **Guidelines on the Management of Urban Green Spaces** (2017[4]). The Guidelines offer technical, scientific, and cultural criteria and tools for the planning, construction, and management of green spaces in urban and peri-urban contexts. For example, it explains how to carry out a census of green spaces, design local regulations, monitor performance (including costs and benefits) of green elements, as well as what instruments to use when planning for urban green spaces. In addition to that, the 2018 Strategy supports local administrations providing a series of technical criteria and guidelines on urban and peri-urban forestry policies. In particular, the Strategy highlights the need to engage the different stakeholders, including local communities, and adopt a multidisciplinary approach (Alleanza Italiana per lo Sviluppo Sostenbile (ASviS), 2022[5]).

In Italy, environmental and ecosystems protection fall under the legislative power of the State (Italian Constitution, Art 117, letter s), while territorial planning is a matter of concurrent legislation between the state and the regions. At the regional level, the regulatory instrument specific to GI is the Regional Ecological Network (REN). The REN is part of Regional Territorial Plan (RTP), which integrates environmental protection in the strategic planning for spatial development at the regional scale. Moreover, there exist some regional initiatives that further integrate GI in spatial planning and can serve as a good example for others to foster their implementation. For example, in Emilia-Romagna, the regional law 24/2017 on urban planning introduced the requirement to assess and consider the ecosystem services for spatial plans of a large-scale (i.e. for the provincial and regional territory). The region Piemonte has also long-standing sectoral legislations and plans – for example, in land management, management of water resources, and protected areas – that promote actions and principles which are key to GI (see Box 4.2 to learn about Piedmont's legislations relevant for GI).

Box 4.2. Piedmont's legislation relevant for GI

The Regional Act 56/1977 et seq. "Soil Protection and Land Use" (Land Planning Act). The Act has been modified many times over the years but maintains its overall structure. It is based on the transversal principle of containment of land consumption (art. 1). The Region and the local bodies carry out their functions for land planning by regulating, with this Act, the protection and limitation of land use, in order to achieve the goal of zero consumption.

The Regional Act of 16th June 2008, no. 14 on "Landscape Valorisation Rule", which intends to preserve the cultural and natural values of the landscape by promoting and implementing policies aimed to landscape evaluation and restoration.

The Regional Act of 10th February 2009, no. 4 (with subsequent amendments and additions) **on "Forest Management and Economical Promotion"**, which is aimed at promoting the sustainable management and the multifunctional role of forests. It considers planning at three different levels: regional, territorial and farm level.

The Regional Act of 29 June 2009 on the Conservation of Natural Areas and Biodiversity. The Act updated Piedmont's regulations for protected areas and recognised a more prominent role to the European Natura 2000 Conservation System. It promotes the creation and consolidation of the Regional Ecological Network, including the System of Piedmont for Protected areas, SACs, Sites of Community Importance (SCIs) and SPAs, ecological corridors and connection in the territory, which must be

identified at the different scales and for improved knowledge. The Act also reintroduces contiguous areas to the protected areas and regards the Environmental Impact Assessment.

The Management Plan of the Po River Hydrographic District – 2015 Water Plan. The Plan aims at reducing pollution, preventing further deterioration and improving the aquatic environment, as well as promoting a sustainable use of water resources and mitigating flooding and drought impacts. GIs are explicitly mentioned as flood protection interventions that simultaneously provide a broad spectrum of ecosystem services.

Source: (Henriette, Neubert and Marrs, 2019[6]; Autorita' di Bacino del Fiume Po, March 2016[7])

4.2. The institutional set-up for GI in Italy

Despite Italy's strengthened commitment to sustainable development and the ecological transition[4], GI is not yet at the centre of the Italian national debate. Not all relevant actors are fully aware, nor they take advantage of its potential to steer the country towards a more sustainable and resilient recovery. Moreover, the institutional set-up governing GI presents roles and responsibilities that are sometimes unclear and fragmented, resulting in inefficiencies, duplication of efforts, and a lack of co-ordination and implementation.

De facto, there exist multiple authorities dealing with GI (e.g. MIT, MASE, public agencies[5], regions, provinces, municipalities, metropolitan cities), but the level of knowledge about what GI is, how it shall be integrated in infrastructure and spatial planning, and how to implement and manage it over its entire lifecycle varies. At the regional and local level, administrations tend to have better competences and more experience with green infrastructures planning and implementation, but the lack of a common national guidance has resulted in heterogeneity in adoption, with some regions and cities performing way better than others (e.g. Lombardy, Emilia-Romagna, Milan, Padua, and Bologna).

Overall, the multitude of actors involved represent an obstacle to the development of an effective framework governing GI at the central level and to their widespread implementation across the national territories.

At the central level, the four main Ministries with competencies relevant for GI are **MIT, MASE, MoC, and the Ministry of Agriculture, Forestry, and Food Security (MASAF)**. They all have certain responsibilities to ensure that environmental and climate considerations are taken into account in infrastructure planning and project appraisal (see Table 4.1). However, reduced co-ordination among them often results in missed opportunities to create synergies across their efforts and develop a consistent institutional framework on GI at the central level.

Table 4.1. Ministerial competences in GI

Ministry	Domain	Competencies in GI planning and implementation
MIT	MIT is responsible for infrastructure planning for sectors like road transport, railway, public transportation, air transport and aviation, water resources, ports and maritime transportation, urban mobility (including "soft" urban mobility) and urban development, and public buildings.	In 2021, the Ministry has defined a new framework for the evaluation and planning of public investments with the scope to promote sustainable infrastructure projects[6]. The new framework introduces sustainability considerations – including environmental protection – in the ex-ante assessment of projects and in project prioritization. This represents an opportunity to integrate GI planning and NbS implementation in public infrastructure investments.
MASE	MASE is responsible for environmental protection and energy security, as well as for the country's ecological transition.	MASE is the ministry in charge of the implementation of the EU Strategy for GI at the national level. Moreover, MASE is responsible (i) for EIA and SEA processes for projects and plans that fall under the State's competence; (ii) responsible for Green Public Procurement and the definition of the Minimum Environmental Criteria to be used in public tenders.
MoC	MoC is responsible for safeguarding the country's cultural heritage, including landscape.	The final decision on EIA and SEA – issued by MASE – must also have the consensus of MoC. The area where a project/plan is realized does not only have an environmental value, but also a cultural one (i.e. landscape).
MASAF	MASAF is responsible for rural development, agriculture and fisheries, forestry, and food quality.	MASAF is responsible for the development and implementation of the National Strategic Plan for the EU Common Agricultural Policy (CAP). The latest version of the Plan recognizes the importance of strengthening GI in rural and agricultural areas to reduce the environmental impacts and enhance the ecological connectivity of green areas (i.e. ecological networks).

Note: MIT (Ministry of Infrastructure and Transport), MASE (Ministry of Environment and Energy Security), MoC (Ministry of Culture), MASAF (Ministry of Agriculture, Food Sovereignty and Forestry)

Another important ministry for infrastructure is the **Ministry of Economy and Finance (MEF)**, which is responsible for the state's budget and public expenditure, as well as for the coordination and planning of public investments. MEF could thus take advantage of its policy and financing instruments to ensure GI and NbS considerations are integrated into public investment and infrastructure projects, for example, by making this a necessary requirement to access public funding. Moreover, it could allocate specific economic resources (e.g. environmental taxes[7]) to finance GI planning and NbS projects.

Two other central-level actors that can support the integration of GI in infrastructure planning and implementation are the Regional Agencies for Environmental Protection (also known as ARPAs) and the Higher Institute for Environmental Protection and Research (also known as ISPRA).

ARPA is part of the Italian public administration, and it is the agency responsible for environmental protection. Each Italian region has its own ARPA[8]. Even though there are differences in the roles and responsibilities of ARPAs across the different regions, they mainly provide technical support to regional and local administrations for environmental protection (i.e. air and water pollution, noise pollution, protection of surface and groundwater, land consumption and soil contamination, biodiversity, etc.). They assist sub-national actors in different areas (see Box 4.3 to know more about the role of ARPA in Lombardy), including territorial and spatial planning, environmental assessments of projects and plans, issuing of environmental authorisations, environmental monitoring, collection of data, training and capacity building, etc.

Box 4.3. The role of ARPA Lombardia to promote GI at the sub-national level

In Lombardy, the regional agency for environmental protection supports spatial planning by providing observations during the environmental assessments (i.e. EIA and SEA) of plans/programmes and projects. Observations focus on environmental aspects – for example, biodiversity, surface and underground water, air and soil pollution – as well as on the interactions with anthropogenic activities. Through this role, the agency promotes the integration of environmental considerations into planning and implementation of infrastructure at the sub-national level, with the scope to improve people's well-being and mitigate the expected negative impacts on the environment.

Strategic Environmental Assessment

In the SEA process, ARPA Lombardia mainly focuses on:

- *Climate change mitigation & adaptation,* through the assessment of climate risks and hazards, the promotion of planning solutions and implementation rules aimed at strengthening resilience against extreme weather events, the promotion of green infrastructure that are properly designed and maintained, the encouragement of urban agriculture and sustainable water drainage systems, and the implementation of NbS;
- *Air quality,* through the preservation and enhancement of green areas, the regeneration of buildings (e.g. cooling and heating systems based on renewable energy source), and the promotion of sustainable urban mobility;
- *Water management*, through the promotion of water saving solutions, interventions to reduce water losses in the existing network, and the development of new systems for recycling and reuse;
- *Soil consumption,* through the urban regeneration of large areas.

Environmental Impact Assessment

In the EIA process, ARPA Lombardia assesses the contents included in the EIS. It reviews the analysis conducted on the environmental components, as well as the criteria, methods, and the timeline of the environmental monitoring - from ante-operam to post-operam. It might also directly supervise the monitoring activities.

To promote environmental monitoring, the agency has developed a series of operational tools that can be used in the design and execution phase. For example, it has recently launched a guidance on the management of alien plant species at construction sites (see https://www.arpalombardia.it/Pages/Valutazioni-Ambientali/PMA.aspx).

Natural resources

The agency's environmental assessments include biodiversity considerations. At the project level, for example, ARPA Lombardia promotes the integration of individual projects within the existing (regional, provincial, and/or municipal) ecological network, as mitigation measures might not be as effective otherwise.

Additionally, since 2021, the agency has been pushing to include climate change adaptation assessments, which analyse the impacts of climate change and resilience capacities. SNPA has recently launched a dedicated course that ARPA Lombardia's staff has attended. Recognising the importance of multidisciplinary skills and knowledge, ARPA Lombardia is planning to develop an integrated approach, also by creating new opportunities for exchange between different professional figures internal to the agency. This will be a stimulus even for actors outside ARPA to start considering GI and NbS as effective tools for climate change resilience in spatial and infrastructure planning.

Source: the information and data contained in the box were directly provided by ARPA Lombardia

ISPRA is the national research institute for environmental protection. It gathers data and statistics on GI planning and implementation across the national territory and develops guidelines and recommendations for public authorities and administrations (at the national and sub-national level). Recently, together with ASviS (*Alleanza Italiana per lo Sviluppo Sostenibile,* i.e. the Italian Alliance for Sustainable Development), it has published the Paper "*Infrastrutture verdi urbane e periurbane*" that takes stock of the existing policies, instruments, and financial resources for urban forestation in Italian cities. It also suggests a series of policy interventions and actions to better equip local administrations for the planning and management of urban green spaces (Alleanza Italiana per lo Sviluppo Sostenbile (ASviS), 2022[5]).

Moreover, ISPRA takes part in the processes for EIA and SEA, providing technical and scientific support to the Technical Commission to evaluate the quality and completeness of the information submitted by the plan/project's proponent. For the SEA, ISPRA also assists MASE and regional competent authorities in monitoring, conducts studies and research to develop new methodologies and instruments for assessments, contributes to improve the national normative framework on the subject and develops guidelines to support plan's proponents and public administrations to go through SEA and comply with the relevant norms (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[8]).

ISPRA together with the 21 ARPAs (including the APPAs - Provincial Agencies for Environmental Protection - of Trento and Bolzano) constitutes **the National Network System for Environmental Protection (SNPA)**. The SNPA was established in 2017 and represents a new entity that helps combine the local knowledge of the territory and environmental issues with national policies on environmental protection. Overall, SNPA carries out different tasks and activities, including: (i) inspections with regards to environmental control functions; (ii) monitoring of the state of the environment; (iii) control of sources and factors of pollution; (iv) research activities to support its functions; (v) technical-scientific support to the activities of state, regional and local bodies with administrative responsibilities in the environmental field; (vi) collection, organization and dissemination of environmental data (Sistema Nazionale per la Protezione Ambientale (SNPA), n.d.[9]).

Through the SNPA Council, the System expresses its binding opinion on the Government's technical measures in environmental matters. Moreover, it can propose to MASE and the Permanent Conference between the State and the regions (including the autonomous provinces of Trento and Bolzano) interventions and solutions (including legislative ones) to align with sustainable development objectives, reduce soil consumption, and safeguard the environment and natural resources (Sistema Nazionale per la Protezione Ambientale (SNPA), n.d.[9]).

4.3. Planning for GI in Italy

4.3.1. The Ecological Network

Spatial planning is a matter of **concurrent legislation between the State and the regions**. In brief, the State is responsible for defining the fundamental principles upon which regions draw and enact more detailed norms. In addition to that, municipalities exercise their administrative functions by means of urban regulatory plans and other planning instruments[9] (Henriette, Neubert and Marrs, 2019[6]). In exercising their role for territorial planning, as well as in all other responsibilities covering environmental matters, regions are called upon to fully comply with the environmental norms defined by the State.

De facto, **GI is often handled at the sub-national level** (e.g. regions and municipalities, provinces, and metropolitan cities -, according to the specific competences defined by the regulatory framework), especially in the management of ecological networks and, more generally, in spatial planning and urban strategy instruments.

The ecological network is an interconnected system of habitats which plays a key role in safeguarding biodiversity, especially potentially endangered plant and animal species. It is made up by central areas (core areas), protection bands (buffer zones) and connection bands (corridors) that allow the cross movements of species (animal and plants) and help reduce the risk of extinction of local populations. It mainly includes protected areas and Natura 2000 sites (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[10]).

In Italy, the ecological network can be defined at different administrative levels (e.g. at the regional or local scale), and it is an important instrument to reduce habitats' fragmentation and ensure ecological connectivity. The extensive work on ecological networks conducted throughout the decades has informed the identification of the territory's environmental potentials, and it has contributed to building detailed scientific knowledge of the many habitats spread across the peninsula. For this reason, ecological networks are key in the national discussion on GI: ecological networks help maintain and strengthen the connectivity between green areas across the national territory, protecting biodiversity and restoring ecosystem services (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[10]; Ministero dell'Ambiente e della Protezione del Territorio e del Mare (MATTM), December 2013[11]).

For over a decade, ISPRA has been studying the issue of ecological connectivity and habitat's fragmentation in Italy. Starting from 1997, the institute has promoted the research initiative "*Ecological Networks, Multiannual plan of activities for the definition of tools for the ecological continuity of the territo*ry", which had the scope to support the implementation of the EU Habitats Directive. One of the main outcomes of this initiatives has been the publication of the *Guidelines for the management of functional ecological link areas* (2003), providing practice-oriented indications on the planning and management of green corridors in land policies.

Traditional planning instruments that integrate and manage ecological networks offer opportunities to integrate GI in territorial development (see Box 4.4). Nonetheless, the capacity and willingness to do so vary across sub-national actors. While some municipalities and regions are front-runner in GI planning, others are lagging behind. Moreover, Italy does not have any comprehensive national legislations in place on spatial planning and urban development. This has led to a proliferation of approaches to planning, which represents an additional obstacle to the development of a common approach to GI across the national territory.

Box 4.4. Sub-national instruments for spatial planning relevant for GI

This box provides a (non-comprehensive) list of the main planning tools at the regional, provincial, and local scale that are currently used and can be further strengthened to integrate GI in spatial and infrastructure planning in Italy. Generally, plans and regulations at higher administrative levels define the reference framework lower-level plans and regulations must comply with.

Regional scale

- **The Regional Territorial Plan** (*Piano Territoriale Regionale,* or RTP) defines the strategic vision for territorial management at the regional level, and considers physical, economic, environmental, and social aspects. In brief, it represents the reference framework for territorial planning and lower administrative levels are expected to comply with it when defining territorial plans and norms. The implementation of the RTP falls under the responsibility of different entities that operate at the regional and local level.
- **The Regional Landscape Plan**[10] (*Piano Paesaggistico Regionale,* or RLP) outlines the sustainable development strategy at the regional scale, and local landscape and urban plans are expected to align with it. Its main objective is to preserve the quality of the landscape and protect the environment. The RLP identifies the **Regional Ecological Network** (REN)[11].

Moreover, it promotes the co-ordination and creates synergies between landscape and sectoral policies. The provisions contained in the RLP prevail to those envisaged in the specific sectoral planning tools.

Provincial scale

- **Territorial Provincial Plan** (*Piano Territoriale Provinciale,* or TPP) and/or **Co-ordination Territorial Plan** (*Piano di Coordinamento Territoriale,* or CTP)[12] outline the strategy for the spatial and territorial planning at the provincial scale, including for road infrastructure, green and protected areas and urban development. In particular, the plan defines the objectives, guidelines and rules for the use and protection of environmental resources. The TPP and CTP are also used to define the **Provincial Ecological Network (PEN**) and promote ecological connectivity. This is the case, for example of the TPP of Turin's provincial territory. The PEN needs to be further detailed and possibly implemented at municipal level, through the Local Urban Plans.
- **Strategic Plan for the Metropolitan City** (*Piano Strategico della Citta' Metropolitana,* SPoMC) contains the development strategy on a provincial scale and it is managed by the Metropolitan City. It mainly coordinates the strategies for economic, social and cultural development of its municipalities. SPoMCs can also provide guidance on interventions at the urban level to protect and enhance ecosystem services as well as support to lower-level administrations to implement the PEN at the local scale, including through GI.

Local scale

- **Local Urban Plans**[13] (*Piano Regolatore Generale Comunale,* LUP) is a tool for urban planning that gives priority to environmental protection and the conservation of the natural resources. For example, in Piedmont region, Local Urban Plans are asked to integrate measures to limit land consumption, as well as to protect agricultural areas, natural and environmental resources, historical-artistic and landscape heritage. Moreover, they must ensure an allocation of 12.50 square meters per inhabitant of public green areas (e.g. urban parks or game and sport areas), to be increased if the population exceeds 20 thousand inhabitants. The LUP is also the instrument that identifies and implement the ecological network at the local scale (**Local Ecological Network or LEN**).
- **Green Urban Plan** (*Piano del Verde Urbano,* GUP) is a strategic tool for urban territorial transformation and green spaces; it mainly defines key principles, criteria, and actions for the management of urban green areas. The 2017 *Guidelines for the management of urban green spaces* defines the guiding principles for municipalities to develop the Green Urban Plan, highlighting its role as complementary tool for urban planning, which defines the city's "green profile". The Green Urban Plan includes measures for the creation and expansion of urban and peri-urban green areas, taking into account existing ecosystems and the natural characteristics of the municipal territory. Moreover, it identifies and strengthens the ecological connectivity of natural and agricultural areas with the urban context - also leveraging blue infrastructures (rivers, canals, etc.), promotes the creation of peri-urban forests and the presence of animal species of natural interests, while avoiding factors that may favour invasive or alien species.

Note: the list of planning instruments provided in this is box is not meant to be exhaustive. Moreover, instruments' names and title might vary across regions.
Source: (Henriette, Neubert and Marrs, 2019[6]; PadovaNET, April 2022[12])

Table 4.2 summarises the main sub-national authorities responsible for spatial planning and territorial development, and the tools at their disposal to integrate GI.

Table 4.2. Sub-national actors involved in spatial planning and tools to promote GI

Authority	Level of government	Instrument
Regional authorities	Regional	Planning instruments for the definition and management of the Ecological Network, Regional Protected Areas, and Natura 2000 Sites. In particular, the RTP and RLP, TPP and CTP.
Metropolitan cities	Provincial	Planning instruments for spatial and urban development, as well as for the management of the Ecological Network, Protected Areas, and Natura 2000 Sites at the provincial scale. In particular, the TPP or CTP and the SPoMC (see footnote 12).
Municipalities	Municipal	Planning instruments for urban planning, including green urban spaces. In particular, the LUP and the Green Urban Plan.

Considering the existing governance framework for GI, there is the need for all the different levels of governments involved in territorial development to coordinate and cooperate. Green infrastructure runs across territories, jurisdictions, and sectors, and often depends on the relationship between a number of elements and processes taking place at different scales (e.g. biological, anthropic, landscape, climate, etc.). In other words, it is hard to imagine that GI can be enclosed in one single planning instrument nor that they can managed by a one specific level of government in isolation (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[13]).

4.4. National policies and strategies relevant for GI

Italy does not have a national strategy or policy specific on GI, and this is one of the major obstacles to the widespread adoption and implementation of GI across the country. Nonetheless, references to this instrument have started appearing in key national policy documents. Just recently, the **Fourth Report on the Status of Natural Capital** in Italy has highlighted the GI potential to reduce the environmental impact and halt biodiversity loss, to restore and enhance ecosystem services, as well as to improve the quality of life in urban and peri-urban areas (Comitato Capitale Naturale, 2021[14]).

Most notably, GI is a key leverage in the **National Strategy for Biodiversity to 2030**. The Strategy is currently undergoing public consultation, but the draft document repeatedly promotes the use of GI to achieve two strategic objectives: (i) build up a robust and connected network of protected terrestrial and maritime areas; (ii) restore terrestrial and maritime ecosystems. Most notably, the Strategy includes the following initiatives and actions (Ministero della Transizione Ecologica (MiTE), 2022[15]):

- The introduction of new criteria, mechanisms and fiscal measures to secure investments in protected areas, green and blue infrastructure, and nature-based solutions, as well as to facilitate the monitoring of their performance and benefits. Data can then be used to inform public decision-makers, improve planning instruments, and build new, more fit-for-the-purpose, financing models.
- Strengthening the considerations of GI and ecological networks in planning instruments and documents for territorial development and public finance. To do so, it encourages the co-ordination across the different administrative levels as well as the improvement of knowledge and technical capacities to manage green infrastructure by public administrations.
- The integration of GI urban and peri-urban areas to halt ecosystem loss, reduce habitat fragmentation and improve the connectivity across the different pieces of the ecological networks. In particular, it asks all the cities with at least 20 thousand inhabitants to develop an urban greening plan and integrate nature-based solutions in urban planning (e.g. green roofs and walls, phytoremediation, parks, green corridors, trees, urban gardens, grassy canals and ditches for drainage, make paved surfaces permeable, etc.).

The country has further mainstreamed GI in other important national strategies and plans, such as 2017 National Strategy for Sustainable Development, the National Strategy and Plan on the Adaptation to

Climate Change, the new Common Agricultural Policy (CAP, or PAC in Italian), as well as in the National Recovery and Resilience Plan (PNRR) and in the Plan for the Ecological Transition.

The **National Strategy for Sustainable Development**, released in 2017 and currently being updated, emphasises the urgency to halt biodiversity and habitat loss in Italy, as well as to protect, restore and enhance ecosystem services. It mentions GI as an important tool to support sustainable agriculture and food security by strengthening resilience to natural disasters (Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM), October 2017[16]).

The 2015 **National Strategy on the Adaptation to Climate Change** promotes the use of GI in forests' management and in the transport sector in order to restore ecosystem services, strengthen resilience to the impacts of climate change and extreme-weather events, especially water-related risks, and support more sustainable public transport modes (i.e. soft/active mobility) (Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM), 2015[17]). The implementation of the Strategy will be guided by the **National Plan on the Adaptation to Climate Change**, issued in 2018, which is still waiting for the final approval on the Strategic Environmental Assessment. The Plan has the role to guide national, regional and local institutions to develop their own adaptation plans, considering context-specific risks, challenges and enabling conditions. It also highlights the benefits of integrating GI in sectoral planning for tourism, forestry, and urban settlements. Benefits include improved territorial connectivity, the mitigation of the impacts of climate change without compromising the landscape, the restoration and enhancement of ecosystem services (e.g. micro-climate regulation, the mitigation of the heat-island effect and the management of heavy rainfall and flooding) (Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM), 2018[18]).

Even at the sub-national level, various initiatives for climate change adaptation have started taking place, and some of them are also integrating GI. A report published by ISPRA in 2019 provides an overview of the efforts taken by regional administrations to cope with climate change. Most notably, it assesses which regions are engaging in the definition, adoption or approval of plans or strategies for climate change adaptation – even at the sectoral level, as well as in which phase they stand in decision-making process. Overall, Italian regional administrations show a relatively good level of awareness of the urgency of the climate crisis and its impacts. However, there are differences across the national territory, and some regions are performing better than others (for more information on initiatives at the sub-national level for climate change adaptation see Box 4.5).

Box 4.5. Sub-national initiatives for climate change adaptation in Italy

Regional level

Of the 15 regional administrations that completed the questionnaire developed by ISPRA in 2019, Lombardy is the front-runner. In 2014, it defined its regional strategy for climate change adaptation, which aligned with the EU recommendations and the national strategic direction. Currently, it is the only Italian region which has yet adopted a regional action plan for adaptation ("*Regional Action Document on Adaptation to Climate Change*"), which puts the strategy in practice and defines priority actions and sectors. Respectively in 2018 and 2019, Emilia-Romagna and Sardegna also set up their strategy for climate change adaptation. Abruzzo is in the process of developing it. In 2018, the region adopted guidelines for the realisation of the adaptation plan and assessed the climate history and profile of its territory.

For the other regions (Friuli Venezia Giulia, Marche, Molise, Piedmont, Apulia, Sardinia, Valle d'Aosta and the Autonomous Province of Trento) have started to prepare their strategies for adaptation, albeit differentiated and at uneven levels of progress. The Autonomous Province of Bolzano is currently

undertaking initiatives aimed at integrating adaptation measures into sectoral policies, although it has not launched any specific initiatives for the preparation of strategies/plans.

Municipal level

Many Italian municipalities have adhered to the **Covenant of Mayors for Climate and Energy**, which brings together local and regional authorities voluntarily committing to implementing the European Union's climate and energy objectives on their territory. Signatories pledge to reduce CO2 emissions by at least 40% by 2030 as well as to increase their resilience to the impacts of climate change. **The Sustainable Energy and Climate Action Plan (SECAP)** template constitutes the standard reporting framework for Covenant Signatories. The SECAP template forms the skeleton of the individual action plans. It serves as a basis for good climate and energy management and for tracking progress in implementation. For some Italian cities, SECAP is part of their strategies and plan for climate change adaptation.

According to the 2022 report published by Legambiente, just a few Italian cities have an adaptation plan in place.

Ancona. Ancona was the first Italian city to adopt, in 2013, a Plan on the Adaptation to Climate Change.

Bologna. Bologna's Plan on the Adaptation to Climate Change (2015) defines objectives as well as operational actions to achieve them. It also includes a monitoring system, that is key for the management and co-ordination of local actions and actors. The Plan envisages the expansion and creation of green areas, including pre-urban parks, planting of trees in urban areas, greening of public buildings with green roofs and walls. It also considers the use of green infrastructure and natural ecosystems to improve the management of water resources and flood risks. In 2018, Bologna municipality has integrated the SECAP to the Plan that now includes an analysis of the vulnerability and adaptative capacity of the territory.

Turin. In 2020, the municipality of Turin issued the Climate Resilience Plan with the scope to mitigate the impacts of climate change on its territory. The Plan also included interventions to improve soil permeability, as well as planting of trees, urban forestry interventions, urban parks, and the use of green roofs.

Genoa. In 2021, Genoa adopted the Action Plan Genoa 2050 that sets out a series of concrete actions for climate change mitigation and adaptation. Most notably, the Plan includes 12 different actions based on the analysis of territorial needs and urgencies. The actions are divided into "grey", "green" and "soft" with objectives in the short-, medium- and long-term. "Green" actions include the realisation of the SECAP.

Padua. In June 2021, the municipal council approved the new Sustainable Energy and Climate Action Plan or SECAP (previous plan from 2011). PAESC identifies 33 actions for climate change adaptation that include improving soil permeability, expanding green urban areas to mitigate the urban heat island effect, as well as the use of green infrastructures to improve the management of water resources in urban areas and flood risks.

Milan. In February 2022, Milan's municipal council approved the Air and Climate Plan. The Plan envisages the expansion and creation of green urban areas, including green roofs and walls, urban forestry interventions, green corridors to connect the urban areas with the surrounding parks, and planting of trees. It also considers the use of NbS for cooling public buildings, such as schools. Moreover, the city of Milan is part of the Metro Adapt Project that promotes the exchange of good practices and instruments for climate change adaptation among municipalities and metropolitan cities. The Project has also the objective to develop a network of Italian and European metropolitan areas to promote the use of NbS for climate change adaptation.

Other cities that have developed strategies for climate change adaptation are Rome and the municipality of Sorradile.

Rome. In 2018, Rome issued its Resilience Strategy as a result of its participation to the 100 Resilient Cities (100RC) Project[14], managed by the Rockefeller Foundation. The Project promotes the resilience of cities through the appointment of a Chief Resilience Officer (CRO), the creation of a Resilience Strategy. and the sharing of knowledge and case studies, via the 100RC global city network and access to a partner platform.

Sorradile. Under the Mayors Adapt Sorradile Project, Sorradile developed a Plan on Adaptation to Climate Change in order to strengthen the resilience of its territory. The innovative character lies in the definition of an approach that is specific to small rural centres and can be replicated in other Italian and European villages. Sorradile is also the first municipality in Region Sardegna to be equipped with such a Plan.

Source: (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), 2019[19]; Legambiente, 2021[20]; Legambiente, 2022[21]; Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), n.d.[22]; Neves et al., 2016[23])

GI is also part of the **National Strategic Plan** (PSN) **elaborated within the Common Agricultural Policy** (CAP) (Ministero delle politiche agricole, alimentari e forestali (Mipaaf), 2021[24]). In particular, among "infrastructures investments with environmental aims", Natural Water Retention Measures are mentioned as a solution to integrate the need to mitigate hydro-geological risk with the protection and restoration of ecosystems and biodiversity. Moreover, in the section on investments for rural areas, the CAP stresses the need to build new GI and reinforce existing GI assets to ensure connectivity and consolidate the regional ecological networks.

The 2021 **National Recovery and Resilience Plan** (PNRR) also considers GI, even if just to a limited extent. Under the EU Recovery and Resilience Facility, Italy will be receiving EUR 191,5 billion and it commits to use a large part of these funds (mainly, EUR 54,46 billion) to support the country's ecological transition. For example, more than EUR 10 billion were allocated to finance sustainable transport infrastructure and mobility solutions within cities. Moreover, with the scope to safeguard air quality and protect biodiversity, the Plan envisages a series of investments for soil protection, restoration of marine ecosystems, maintenance and improvement of existing green areas, as well as for the creation of new green spaces. In particular, it allocates EUR 300 million to the planting of 6.6 million trees (at least 1.6 million trees by 2022) in the 14 Italian Metropolitan Cities[15] (Governo Italiano, 2021[25]).

The 2021-2050 **Plan for the Ecological Transition (PTE)**[16] aligns with the PNRR and defines the environmental measures and a timeline to achieve the green objectives set at the international and European level (see the EU Green Deal) by 2050, including climate neutrality and the adaptation to climate change. One of the key areas of intervention is biodiversity and the scope is to halt biodiversity loss, as well as to protect and restore the country's flora and fauna. In this regard, green infrastructures are often mentioned in the text. More specifically, the Plan intends to strengthen and expand protected areas across the national territory, implement green solutions, such as green corridors or the re-naturalisation of rivers, to improve the ecological connectivity, adopt NbS for the restoration of degraded ecosystems, especially in the urban context, as well as strengthen the monitoring of habitats and species to improve policy making and enhance efforts where needed (CITE, 2021[26]).

4.4.1. The role of the Strategic Environmental Assessment (SEA): Strengthening GI considerations in SEA

In Italy, the Strategic Environmental Assessment is governed by Legislative Decree 152/2006[17], which transposes the EU SEA Directive (Directive 2001/42/EC) into the national legislation. The SEA is carried

out at the plan/programme level for plans, programmes or policies that fall under the competence either of the State or of the regions. **Its final scope is to assess the environmental impacts of plans (or programmes and policies) to inform the design process, as well as the process for approval and implementation**. For this reason, the SEA must be performed before the plan (or programme and policy) receives the final approval and is implemented. (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[27]).

As a legally required and specifically defined process, the SEA provides an opportunity to systematically integrate GI considerations in a standardised approach into plans, programmes, and policies. Most notably, it requires planners to consider environmental and climate aspects at an early stage of development, when alternatives are still open. Moreover, GI considerations in SEA are likely to feed into the planning of any projects resulting from the implementation of the plan (or programme and policy), as well as in any associated environmental impact assessments.

For plans/programmes/policies that fall under the State's competence, MASE is the authority responsible to deliver the **reasoned opinion** – in agreement with the Ministry of Culture (MoC) - which concludes the SEA process. The reasoned opinion is informed by results of the consultation process[18] and by the support of the Technical Commission for the SEA, which provides technical and scientific assistance to the Ministry (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[27]). It sets outs recommendations and conditions the plan (or policy and programme) must comply with and also contains the monitoring plan. The monitoring of the environmental performance of the plan (or policy and programme) and its compliance with sustainability and environmental targets is key to identify unforeseen adverse impacts in a timely manner and take appropriate corrective actions. The proceeding authority, in collaboration with the competent authority (i.e. MASE for plans under State's competences), is responsible for monitoring. Moreover, it can rely on the support and instruments provided by the Environmental Agencies across the national territory and the Higher Institute for Environmental Protection and Research (ISPRA) (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[27]) (Governo Italiano, 2006[28]).

The regulatory framework governing the SEA process envisages the development of the **environmental report** by the plan's proponent with the scope to identify, describe, and assess the significant impacts on the environment, and consider different alternatives according to the objectives and territorial scope of the plan (or programme and policy) (Governo Italiano, 2006[28]). The environmental report already provides opportunities to integrate GI considerations. For example, biodiversity, climatic factors, and flora and fauna are specified in the list of factors to be considered, and also the interrelationship between all listed factors[19] must be assessed. Moreover, the report should consider any existing environmental problems relating to the areas designated under the Habitats and Birds Directives (European Commission, 2013[29]).

To further strengthen GI considerations in SEA, in 2013, the European Commission issued a guidance document to integrate climate change and biodiversity as standard procedure in strategic environmental assessments (see Box 4.6). The document also suggests consulting the guidance manual "Integrating Ecosystem Services in Strategic Environmental Assessment: a guide for practitioners", which explains how to better integrate ecosystem assessment, scenario development and economic valuation of ecosystem services into development planning at various scale (national, sub-national and local) (see Box 4.7). GI considerations in SEA process can be integrated not only in the environmental report by the plan's proponents, but also by the approving authority (e.g. MASE) in its assessment of the report and through the recommendations and monitoring measures set out in the reason opinion.

Box 4.6. Guidance on integrating climate change and biodiversity into strategic environmental assessment

The Guidance identifies the three main challenges in addressing climate change and biodiversity in SEA and proposes an approach to tackling them. This is summarised in Table 4.3.

Table 4.3. Tips on tackling the challenges related to climate change and biodiversity considerations in SEA

Key challenges to considering climate change and biodiversity in SEA	Tips on tackling these challenges in SEA
Long-term and cumulative nature of impacts	• Avoid "snapshot" analyses and consider trends *with and without* the proposed plan (or programme or policy)
Complexity of the issue and cause-effect relationship	• Analyse impacts of proposed plan (or programme or policy) on the key climate change and biodiversity trends and their drivers • Work with worst-case and best-case scenarios
Uncertainty	• Acknowledge assumptions and limitations of current knowledge • Base your recommendations on the precautionary principle • Prepare for adaptive management

Source: (European Commission, 2013[29])

Building on this, it then provides guidance on how to identify key climate change and biodiversity issues, as well as on how to assess effects related to climate change and biodiversity in SEA.

How to identify key climate change and biodiversity issues in SEA (screening and scoping phase)

- Identify the key issues from a climate change and biodiversity perspective early in the SEA process to ensure they are assessed effectively throughout the process. However, some flexibility must be maintained to address new issues as they emerge during the process.
- Early engagement of stakeholders (environmental authorities, local communities, experts, public agencies, the wider public, etc.) is also important as it guarantees all relevant aspects are taken into account and it helps build agreement to a consistent approach to implementation and monitoring.
- The SEA should consider not only the impacts of a policy (or programme/plan) on climate change and biodiversity, but also the impact of a changing climate and natural environmental on the policy (or plan/programme) itself. The issues and impacts relevant to any particular SEA depend upon the specific circumstances and context of each policy (or plan/programme) (e.g. the type of policy, the sector covered, its location, scale and the characteristics of the receiving environment, institutional and governance arrangements, etc.). Moreover, it is important to consider the interaction and the potential synergies and conflicts between different environmental factors.
- Investigate how climate change mitigation and adaptation interact with each other (e.g. remember that a positive effect on climate change mitigation may lead to negative effects on adaptation, etc.).
- Use ecosystem services to provide a framework for assessing the interactions between biodiversity and climate change.

How to assess effects related to climate change and biodiversity in SEA

- Consider climate change scenarios at the outset, including extreme climate situations and unexpected events that may either adversely affect implementation of the policy (or plan/programme) or worsen its impacts on biodiversity and other environmental factors. The scenarios to consider depends on the nature of the policy and key issues identified at the scoping stage.
- Analyse the evolution of the baseline environment *with and without* the implementation of the plan. The analysis should include trends in key environmental factors or issues over time, the drivers for change, thresholds and limits, areas that may be particularly adversely affected and key distributional effects. Use vulnerability assessments to help assess changes to the baseline environment and identify the most resilient alternative(s).
- Take an integrated, 'ecosystems' approach to planning and examine the thresholds and limits.
- Look for opportunities for enhancement. Ensure that the policy under scrutiny is consistent with other relevant policy objectives, and priority actions for climate change and biodiversity.
- Assess alternatives that make a difference in terms of climate change and biodiversity effects — review the need, the process for its implementation, locations, timings, procedures, etc. - and alternatives that enhance ecosystem services.
- First seek to avoid biodiversity and climate change impacts and then opt for mitigation measures. Seek 'no-net-loss' of biodiversity.
- Assess climate change and biodiversity synergistic/cumulative effects. Moreover, causal chains/network analysis may be helpful to understand interactions.
- Monitor the effects of the policy on climate change and biodiversity and take remedial actions where needed. Climate change and biodiversity indicators should be part of the monitoring proposal in the SEA. Moreover, effective monitoring systems help integrate a more adaptive management[20] into the SEA and promote flexibility and adaptive capacity.

Source: (European Commission, 2013[29])

Box 4.7. Integrating ecosystem services in strategic environmental assessment

This Guidance document proposes a new methodological approach to integrate ecosystem services in SEA, divided into four stages each comprising two or three specific tasks:

Stage 1: Establish the ecosystem service context

Task 1.1: Identify and map ecosystem services and beneficiaries

- Link ecosystems, services and beneficiaries through a conceptual framework.
- Include all ecosystem services to see later which ones are the most important.

Task 1.2: Review existing regulations concerning ecosystem services

- Analyse the possible implications for the strategic action of existing regulations that set conditions for the use or protection of ecosystem services.

Task 1.3: Identify links with other strategic actions

- Harmonize the strategic action with existing actions at different tiers (national, regional and local).
- Identify possible conflicts and synergies related to the supply or demand of ecosystem services.

Stage 2: Determine and assess priority ecosystem services

Task 2.1: Determine priority ecosystem services

- Identify: a) the services upon which the strategic action depends, and b) the services that the strategic action may affect (positively or negatively).
- Consult all potentially affected stakeholders to properly set the boundaries of the SEA.
- Address the geographical relationships between the area where the ecosystem services are produced, and the area where they are used by beneficiaries.

Task 2.2: Assess baseline conditions and trends for priority ecosystem services

- Analyse the current state and likely evolution of priority ecosystem services to understand: the distribution of services and benefits provided to different groups of people, key direct and indirect driving forces, likely future trends (and relevant drivers), threats and opportunities.
- According to context, assess ecosystem services in a qualitative or quantitative way, and by using monetary or non-monetary measures.

Stage 3: Identify alternative and assess impacts on ecosystem services

Task 3.1: Identify alternatives

- Consider an appropriate “hierarchy of alternatives”, from the more strategic to the most operational ones. Task 3.3: Identify measures to enhance and mitigate impacts • Seek measures that, in order of priority: - Enhance ecosystem services - Avoid negative effects on ecosystem services - Reduce negative effects - Repair negative effects - Off-set negative effects

Task 3.2: Predict and evaluate impacts for each alternative

- Determine which ecosystem services would benefit or be worse off, and which groups of people would win or lose, if a given alternative is selected.
- Predict impacts by describing the expected changes in the ecosystem services conditions due to the implementation of a given alternative.
- Evaluate impacts by describing the significance of the predicted changes for beneficiaries.
- Address cumulative effects, by considering all activities of the strategic action, as well as of other existing/ foreseen action.
- Make ecosystem services trade-offs and synergies explicit.

Task 3.3: Identify measures to enhance and mitigate impacts

- Seek measures that (in order of priority): (i) enhance ecosystem services, (ii) avoid negative effects on ecosystem services, (iii) reduce negative effects, (iv) repair negative effects, (v) off-set negative effects.

Stage 4: Follow-up on ecosystem services

Task 4.1: Monitor and manage ecosystem services during implementation

- Collect evidence about contextual changes and actual impacts of the strategic actions on ecosystem services and evaluate to what extent they differ from predictions.

- Propose management interventions and adjustments to the strategic action early enough to improve its overall performance in terms of ecosystem services.
- Communicate results and involve stakeholders in monitoring, evaluating and managing as appropriate.

Task 4.2: Test the quality of the SEA

- Test the process iteratively, to highlight shortcomings and limitations and propose changes when they can materially be used to improve the strategic action.
- Disseminate lessons learned from quality control checks to improve the future practice of integrating ecosystem services in SEA

Source: (UNEP, 2014[30])

4.5. Integrating NbS in project planning appraisal and procurement

Infrastructure projects are likely to have impacts on biodiversity, including changes in the ranges of species and habitat types, as well as in ecological dynamics and ecosystem functions. This also implies changes – and potential disruptions - in ecosystem services, in terms of quality, quantity, spatial and temporal distributions (e.g. timing and quantity of water cycling, soil formation, nutrient cycling, etc.) (Geneletti, Cortinovis and Zardo, 2016[31]). Within the Italian framework governing the permit process and the appraisal and procurement of public investments, there are different instruments to assess projects' impacts on biodiversity and ecosystem services and promote the implementation of NbS. NbS can help mitigate expected negative impacts on different environmental factors, restore degraded habitats, protect animal or plant species, safeguard and enhance ecological connectivity across green areas. Even through NbS considerations are not yet an ordinary practice in the projects' approval and appraisal process, existing tools can be further strengthened towards this purpose.

4.5.1. The role of the Environmental Impact Assessment (EIA): Strengthening NbS considerations

The Environmental Impacts Assessment (EIA) is a legally required instrument for projects' approval and offers an opportunity to systematically integrate environmental considerations relevant for NbS into a wide range of infrastructure investments. Even though both the EU Directive and the Italian national legislation on EIA contain a number of principles that promote NbS considerations, this is not done on an ordinary basis. Most notably, the EIA assesses projects' impacts on, for example, biodiversity, soil, landscape and climate, but NbS aspects are not yet explicitly included in the requirements of EIA procedures. Moreover, NbS-related issues are complex and multi-faceted, and do not lend themselves to simple or quick analyses.

The EIA assesses a project's impacts on environmental and human health factors with the scope to prevent any adverse effects (i.e. principle of preventive action[21]). Most notably, it considers significant direct and indirect impacts on (Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[32]):

1. Population and human health;
2. Biodiversity - with particular attention to the species and habitats protected under the Directive 92/43/EEC and Directive 2009/147/EC;
3. Land, soil, water, air and climate;
4. Material goods, cultural heritage, landscape;
5. The interaction among all the factors listed above.

In Italy, the environmental assessment of projects is based on the EU Directive on EIA[22], which has been transposed into the national legislation and integrated in the national legislative framework on the environment. Today, the EIA is regulated by the Legislative Decree 152/2006[23] (also known as the Environment Code).

The main output of the EIA process is the **Environmental Impact Study (EIS)** that is prepared by the project's proponent and should follow the 2017 guidance by the European Commission "Environmental Impact Assessments of Projects – Guidance on the preparation of the Environmental Impacts Assessment Report". Accordingly, the EIS includes (Governo Italiano, 2006[28]; Ministero delle infrastrutture e dei trasporti (MIT), 2021[33]):

- A description of the project (e.g. location, design, size and other characteristics);
- A description of the likely significant effects on the environment, including in the construction, operation and dismissal phase;
- A description of the measures envisaged to avoid, prevent or reduce and, where possible, compensate for the likely significant and negative environmental impacts;
- A description of the reasonable alternatives considered by the proponent, with an indication of the main reasons for the chosen option;
- The monitoring plan;
- Any additional information on the project and on the environmental factors likely to be affected;
- A non-technical synthesis to summarise the main content and results of the Study.

The EIA can either take place at the national or regional level according to the type and scale of the project. For the projects that fall under the State's competence, the responsible authority is the **Ministry of the Environment and Energy Security** (MASE). More specifically, MASE has a **Technical Commission** in place[24] that assesses the EIS along with other analyses, studies and documents related to public investment projects, including infrastructure projects, and provides its reasoned opinions (intermediate or final), including recommendations or prescriptions, to the relevant Directorate General[25] within the Ministry.

The final decision on EIA is taken with a decree by MASE, which defines the environmental conditions for the implementation, operation, and disposal of the project. The decree can also include recommendations, and request for changes and other measures to avoid, prevent, reduce or off-set negative environmental impacts. Moreover, MASE needs to coordinate with the **Ministry of Culture** (or MoC). Both ministries need to give their approval on the EIA as the territorial context in which a project is realised does not only have an environmental value, but also cultural one (i.e. landscape). The co-ordination between MASE and MoC is thus key to ensure the project's area is managed properly, but it is often hard to find a common agreement as environmental needs might be in conflict with cultural requirements.

The competent authority (either at the national and/or regional level) and MoC are also responsible for checking on the compliance with the EIA procedure. In particular, they have the task to identify, in a timely manner, any possible violations to the EIA requirements or to the environmental conditions set out in the final decision, as well as unexpected environmental impacts. The competent authority can then act in different ways according to the issue at stake, and this includes apply corrective measures, withdraw the previously adopted decision on EIA, require a new environmental impact study, send a warning to the project's proponent to comply with the environmental conditions within a certain deadline, apply pecuniary sanctions, require a suspension of the project implementation, and others (Governo Italiano, 2006[28]; Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[32]).

With the aim to foster the implementation of the EU GI Strategy across Member States, in 2013, the European Commission issued the "Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment" (2013[34]). Given the close interlinks between these topics and NbS, the Guidance represents a key instrument to guide projects' developers and proponents, as well as

approving authorities to take advantage of EIA to promote NbS (see Box 4.8). NbS considerations can be integrated not only in the environmental impact study and the monitoring plan developed by projects' proponents, but also in the assessment carried out by the approving authority (i.e. MASE) through the conditions set out in its final decision, as well as during its monitoring activity and in the definition of corrective measures.

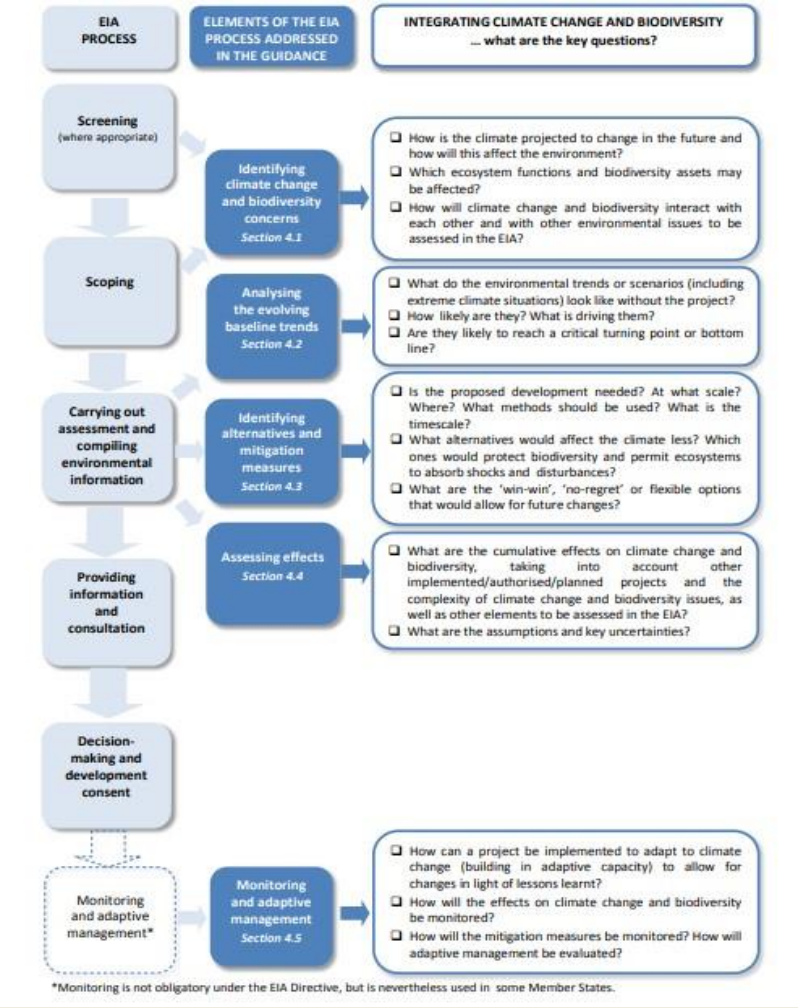
Moreover, under the PNRR, a Special Environmental Assessment needs to be performed to verify projects' compliance with the DNSH Principle. This procedure already offered an opportunity to integrate NbS considerations in EIA – as well as SEA. As defined in the "Operational Guidance on the Compliance with the Principle of Do No Significant Harm (DNSH) to the Environment" (2021[35]), the project's proponent should ensure that all DNSH requirements and constraints are assessed in the environmental permit procedures (e.g. SEA and EIA). Accordingly, nature-based solutions aimed at preventing negative impacts on the biodiversity and climate change adaptation objectives are expected to be part of the EIA.

The Operational Guidance also provides "data sheets" for different types of projects that sets out the criteria to assess compliance with the DNSH. For projects concerning the construction of wastewater treatment plans (see the data sheets n.24), it explicitly states that, under the pollution prevention and reduction objective, NbS measures aimed at avoiding and mitigating excessive rainwater overflows shall be part of preliminary documentation submitted by the project's proponent for environmental permit processes (Ministero dell'Economia e delle Finanze (MEF), 2021[35]).

Box 4.8. Guidance on integrating climate change and biodiversity into EIA

The Guidance provides advice on how to ingrate climate change and biodiversity into selected stages of the EIA process. It also defines a series of questions to help the implementation.

Figure 4.1. Overview of how to integrate climate change and biodiversity considerations into key EIA stages



Note: the figure gives an overview of how to integrate climate change and biodiversity issues into the EIA process, as well as where information on specific EIA stages can be found in the Guidance
Source: (European Commission, 2013[34])

Despite a long-standing tradition and experience with environmental impact assessments - often anticipating the evolution of the EU legal and regulatory framework -, the EIA procedure in Italy still faces some challenges that run the risk of hampering the opportunity to integrate NbS considerations:

- In Italy, the EIA is mainly used to verify projects' conformity with national and EU environmental norms. Beyond this verification, Italy could benefit from using this tool as an instrument to effectively prevent and reduce negative impacts on the environment and to promote ecological connectivity (e.g. by promoting the use of NbS).
- Recently, the country has committed to simplify procedures for the environmental assessments of projects[26]. In 2021, the country approved the Legislative Decree 77/2021, also known as the ***Simplification Decree bis***[27], which gave a boost to the country's effort to streamline

environmental procedures in order to ensure the implementation of the projects financed with the PNRR funds[28] - as well as for the projects of the National Plan for Complementary Investments (PNC) and the 2030 **Integrated National Plan for Energy and Climate (PNIEC)**. In particular, the Decree has accelerated the timeline for the delivery of the final decision on EIA. For the PNRR/PNC/PNIEC projects that fall under the State's competence, a special PNRR-PNIEC Technical Commission – which is internal to MASE – has been given the mandate to work full-time on EIA. This is expected to speed up the overall process and help overcome many of the main criticalities associated with the work of the ordinary Commission on EIA/SEA. Moreover, the time and terms for public consultations for PNRR and PNIEC projects have been reduced.

Beside the potential benefits resulting from the streamlining of procedures, an excessive simplification may negatively affect the opportunity for the competent authorities to gather all the necessary information to be fully aware of a project's environmental consequences and make the appropriate recommendations.

- Environmental monitoring helps keep track of the expected environmental impacts to develop corrective actions, as well as to assess the wide range of benefits (environmental, social, and economic) provided by NbS and promote their implementation. While environmental monitoring plans are often envisaged as part of the approval process, they are not always followed by the responsible authorities. After the EIA has been approved there are limited legal, economic, and institutional incentives to carry out a comprehensive monitoring of the environmental impacts of the project.

4.5.2. The new evaluation and planning framework to promote sustainable and resilient infrastructure by MIT[29]

In order to align with the UN Agenda 2030 and the ambitious EU environmental objectives, Italy has recently adopted a series of initiatives to promote sustainable public investments and support the country's ecological transition.

According to the 2019 Climate Decree, on 1 January 2021, the Inter-ministerial Committee for Economic Planning (CIPE) was transformed into the Inter-ministerial Committee for Economic Planning and Sustainable Development (CIPESS) with the mandate to ensure that public investments contribute to national sustainable development objectives. CIPESS will now assess public projects' alignment with Sustainable Development Goals (SDGs) and the National Strategy for Sustainable Development[30] (SNSVS), as well as their performance according to the Equitable and Sustainable Welfare (BES) indicators (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]). Moreover, in December 2021, the Italian Prime Minister Mario Draghi issued the Directive "*Guidelines on the action of the Inter-ministerial Committee for Economic Planning and Sustainable Development for the year 2022*". The latter gave start to the institutional process to define the new criteria and methodologies administrations will have to consider when submitting their proposals to the Committee. The final purpose is to strengthen the role of public investments in promoting the country' sustainable development (Il Dipartimento per la programmazione e il coordinamento della politica economica, (DIPE), 7 December 2021[37]).

Building on this impetus, MIT has defined **a new framework for the planning and evaluation of infrastructure projects**, which pays due attention to the different dimensions of sustainability (i.e. economic and financial, social, environmental, institutional and governance). More specifically, sustainability considerations are integrated in the planning, as well as in the prioritisation of infrastructure projects and in their implementation.

The new framework includes (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]):

1. An update of the guidelines for the ex-ante evaluation of public projects, together with new operational guidelines specific to sectors[31] (e.g. railway, road transport, water, public buildings, etc.);
2. A new scoring system, also known as SIMS, to assess infrastructure proposals along the different sustainability dimensions and define an order of priority for projects' financing;
3. New guidelines for the drafting of the Technical and Economic Feasibility Project (PFTE) for the infrastructure projects financed with the PNRR funds[32];
4. New guidelines on how to conduct Public Debate for public investment projects.

The Ministry has also created a new **Centre for Innovation and Sustainability in Infrastructure and Mobility** (also known as **CISMI**) to support the research and development of innovative analytical and methodological tools to evaluate the sustainability aspects of public investment projects and their long-term impacts. The Centre will coordinate with other ministries, as well as with the academia and other researchers - both at the national and international level (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]).

Even though none of the instruments and initiatives envisaged by new framework explicitly integrates NbS considerations, they all offer opportunities to promote their implementation. Indeed, nature-based solutions are key instruments to enhance the sustainability and environmental performance of infrastructure projects. For this reason, MIT should start refining its new evaluation framework to also consider public investments' impacts on biodiversity and ecosystem services, as well as their advantages in terms of ecological connectivity. These considerations should be given a primary role in projects' selection and prioritisation.

Under the National Operational Programme for Infrastructure and Networks 2014-2020, the Environmental Task Force within MIT integrated a set of environmental criteria for the selection and award of projects to be financed with EU resources (see Box 4.9). These criteria represent a good example of integration of considerations relevant for NbS in the assessment of infrastructure projects.

Box 4.9. Integration of environmental considerations in the selection and award of projects funded with EU resources

The National Operational Programme for Infrastructure and Networks (NOP I&N) 2014-2020

The programme aligns with the EU priorities and objectives in the field of transport infrastructure. It aims at strengthening the economic, social and territorial cohesion of Italy by improving the mobility conditions for people and goods and promoting the development of the southern Italian regions (Basilicata, Calabria, Campania, Puglia e Sicilia). The priority areas of intervention include:

1. Strengthening railway lines, improve quality and reduce time for travel in railway transport;
2. Improve the competitiveness of the harbour and inter-harbour system;
3. Improve regional mobility by fostering modal integration and multi-modal connections;
4. Optimise air traffic with improved systems and controls;
5. Reduce losses in the water distribution networks, including with digitalisation and monitoring

Environmental criteria

The NOP I&R 2014-2020 integrated a set of environmental criteria for the selection and award of the projects to be financed. These criteria are also reflected in the set of indicators used for the monitoring of SEA. Such a monitoring exercise is fully integrated with the physical, financial and procedural

monitoring of the PON and aims at assessing the effects of the Program and the achievement of certain environmental objectives.

The European Commission has recognised the experience of the NOP I&R 2014-2020 as a good practice example for the integration of environmental considerations in the selection of projects supported by the European Structural and Investment Funds (see https://op.europa.eu/en/publication-detail/-/publication/25295fb0-c577-11ea-b3a4-01aa75ed71a1).

Moreover, some of these criteria (listed below) assess aspects and dimensions which are relevant for NbS, supporting their adoption at the project-level.

Assessment criteria

- Mitigation of possible interferences with protected natural areas (i.e. SIC/SPA/SAC)
- Interferences with hydrogeological constraint zones (R.D. 30 DECEMBER 1923, N. 3267 AND R.D. 16 MAY 1926, N. 1126, landscape and archaeological (D.LGS. N.42/2004)
- Protection of the hydro-morphological characteristics of surface water bodies (river and coastal marine areas)
- Vulnerability to natural hazards
- Impact on acoustic climate and ambient air quality and climate
- Resilience to climate change
- Completion of ecological network connections
- Protection of the quality of surface and underground water bodies

Award criteria

- Adoption of Green Public Procurement practices
- Containment of soil consumption and waterproofing
- Environmental redevelopment of degraded or abandoned residual areas
- Improving energy efficiency and reducing energy and water consumption

Source: the information contained in this box have been directly provided by MIT in the questionnaire submitted to the OECD

The new guidelines for the ex-ante valuation of public projects: The new feasibility project

The revised version of the guidelines for the ex-ante valuation of public investments requires projects' proponents to draft a **feasibility project**. The latter includes an assessment of the project along its key dimensions - economic and financial, social, **environmental**, institutional and governance –, a sectorial analysis, and it also compares the different design alternatives. The results of this preliminary analysis will later be used in the process to inform the screening phase (i.e. whether a given project will be financed or not) and the scoring mechanism (SIMS) (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36])

With regards to the environmental dimension of the project, both its negative and positive impacts are assessed:

1. The project's substantive contribution to the six environmental objectives defined by the European Commission in the EU Taxonomy (i.e. climate change adaptation and mitigation, circular economy, water resources, pollution, biodiversity and ecosystems).
2. The project's compliance with the Do No Significant Harm (DNSH) Principle for all the six environmental objectives.

Moreover, the feasibility project includes a carbon footprint estimate for the construction phase of the project through a certification scheme[33] and an assessment of the project's emission balance along its entire lifecycle, including the operational phase. Emissions impacts are eventually compared across different scenarios, including the "do-nothing" (for example, the impact of climate-altering gas reduction favoured by the modal shift as a consequence of the new infrastructure) (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]).

The new scoring system: SIMS

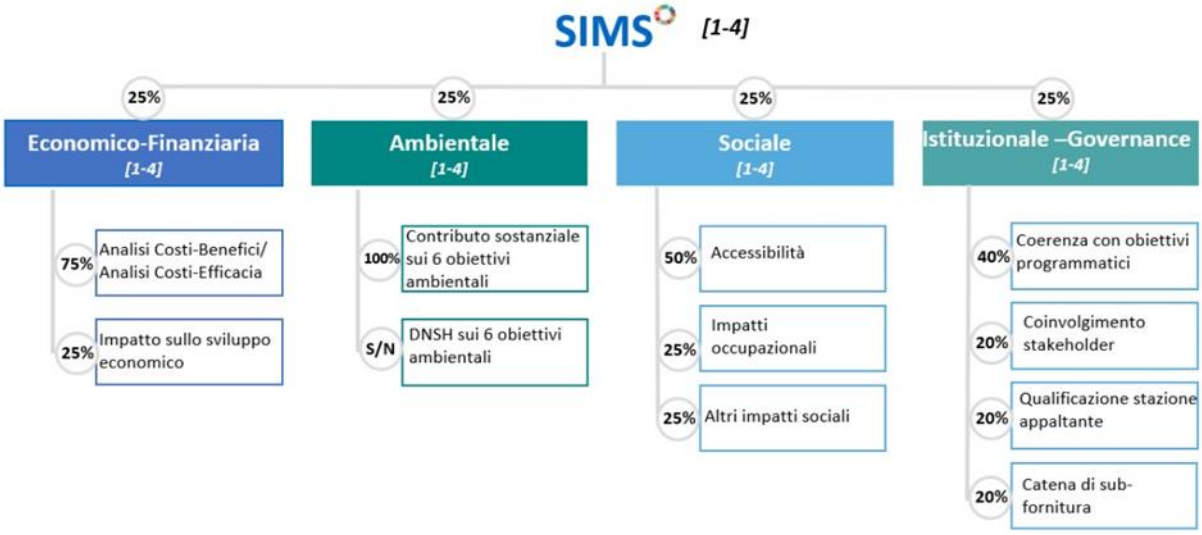
SIMS' main role is to help define an order of priority for project financing on an annual basis. Conceptually, it can be applied to any infrastructure proposals, but the level of detail can adapt to the projects' characteristics and scale (i.e. proportionality), as well as to the knowledge level, capacities and resources of the different public administrations. Moreover, the scoring system provides the ministry with a methodological approach for the selection and prioritisation of investment projects and makes the decision-making process more transparent and accountable to public citizens. It can also be used to support the monitoring during the construction phase of the project to keep track of the expected impacts and/or check on compliance with commitments made at the proposal stage (for example, the use and recycling of materials, control over the sub-supply chain, employment impacts, stakeholder involvement). Results from monitoring can then be shared with the project's proponent, contracting authorities, and the other entities responsible for implementation (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]).

SIMS is based on multi-criteria analysis and evaluates both qualitative and quantitative criteria. More specifically, it assesses projects across four different dimensions, which are broken-down into sub-domains with their specific components of analysis, indicators and qualitative information.

1. **Economic-financial dimension**, which considers the results of the cost-benefit analysis (CBA) and cost-efficacy analysis (CEA), and the analysis of the project's impacts on the territory's economic development;
2. **Environmental dimension**, which considers both the substantial contributions to one or more environmental objectives as defined by the EU Taxonomy and as the compliance with the DNSH Principle (see Box 4.10);
3. **Social dimension**, which considers the project's impacts on accessibility and territorial inequalities, employment, and potential benefits to the people involved;
4. **Institutional and governance dimension**, which is broken down into the level of coherence with national and European strategic orientations, stakeholder engagement, qualification level of the contracting authority, and control mechanisms on the supply chain or other indicators for the quality of governance.

The evaluation of each sub-domain is performed on a discrete scale of 4 levels [1 min; 4 max], that is continuous and linearly increasing (see Figure 4.2). The final rating is a weighted average of the score received in each of four dimensions, which is in turn determined by the score received in each sub-domain (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]).

Figure 4.2. SIMS: The new scoring system



Source: (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36])

The weight structure is flexible as to reflect the evolution of the Ministry' objectives and priorities. Besides, in order to ensure some standardisation of the quantitative and qualitative criteria used for the scoring, MIT has developed guiding grids. This promotes homogeneity of the final results, and it is key to reduce subjectivity and ensures comparability of projects across different sectors (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36])

Overall, SIMS helps the Ministry to make better choices in project financing and effectively contributes to the country's sustainable development and resilience. Even though it increases the workload for projects' proponents, its main advantage is the creation of a new fiscal leverage that drives them to adopt a more sustainable approach to design infrastructure projects. The system was initially developed with the purpose to help MIT align with the new guidelines for the approval of public investments by CIPESS, but it now aims to become a good practice example that other ministries can adopt and adapt to their own needs.

Box 4.10. Evaluation of the environmental dimension (according to the operational guidelines for the railway transport)

For ex-ante valuation of project along the environmental dimension, the main references are the InvestEU regulation and the EU Regulation 2020/852. As previously anticipated, the assessment process considers both the positive and negative impact of a given project on the environment. On one side, it evaluates the "substantial contribution" to one or more of the six environmental objectives[34] identified by the EU Taxonomy. On the other side, compliance with the DNSH Principle

To evaluate the "significant" contribution to the six environmental objectives, the following steps are taken:

1. The technical screening criteria adopted by the EC in the Delegated Regulation 2021/2139 of 4 June 2021 are used to determine the "substantial" contribution of the intervention to climate change adaptation and mitigation (to be supplemented with any technical screening criteria for environmental objectives relevant to the sector as soon as the relevant Delegated Regulation by the European Commission is available);

2. Calculate the percentage of this contribution on a scale from 0% to 1%.

To assess compliance with the DNSH, the procedure suggested by the EC is followed:

1. A preliminary assessment to determine whether an intervention might cause a significant damage to one of the environmental objectives;
2. If so, a more detailed assessment of the intervention is undertaken in order to confirm the negative impact, and thus to exclude the intervention from eligibility for funding.

Source: (Struttura Tecnica di Missione per l'indirizzo strategico, lo sviluppo delle infrastrutture e l'alta sorveglianza, October 2021[38])

The new guidelines for PFTE: the introduction of the Sustainability Report (Relazione di Sostenibilità)

The Technical and Economic Feasibility Project defines the project's design and implementation[35], and it includes an assessment of the environmental sustainability of the project, also known as the **Sustainability Report** (*Relazione di Sostenibilita' dell'Opera*)**.** For the environmental dimension, the Sustainability Report contains:

- An assessment of the projects' impacts and contributions – either positive or negative – to national sustainable development objectives (e.g. the National Strategy for Sustainable Development and the National Strategy for the Ecological Transition);
- An assessment of project's compliance with the DNSH principle and its substantial contributions to the six environmental objectives identified in the EU Taxonomy Regulation (852/2020);
- An estimation of the project's carbon footprint and energy balance, across its entire lifecycle;
- A lifecycle assessment of the circularity dimension of the project (i.e. re-use of construction materials, use of second-raw material for construction, waste production, etc.);
- A resilience analysis which considers all possible risks to the infrastructure and their associated probability. Results are then used to develop solutions that help mitigate project's vulnerability (e.g. extreme weather events).

For the public investments subject to EIA, the PFTE also includes the **Environmental Impact Study** and the **Preliminary Environmental Monitoring Plan** (Ministero delle infrastrutture e dei trasporti (MIT), 2021[33]).

4.5.3. Public Procurement of NbS

Recently, countries have been strengthening their commitments towards sustainable development and environmental protection, and effective public procurement strategies (from the choice of the delivery mode to the definition of award criteria and contract management) are a key tool they can leverage to meet these promises. To achieve this, public procurement practices and regulatory frameworks must align with long-term development objectives and enable decision-makers to deliver infrastructure projects that bring economic, environmental and social benefits all at once, maximising the value generated for the society as a whole (OECD, 2021[39]). In particular, the regulatory and policy frameworks governing procurement can be improved to correct any distortive incentives and set out the necessary legal and economic conditions to promote nature-based solutions (OECD, 2021[40]).

OECD countries spend almost 13% of their GDP in public procurement, especially in sectors like telecommunication, healthcare, construction, and public transport (OECD, 2021[41]). With the upcoming European funds provided under the Next Generation EU Plan, the number of public investments going through public procurement is expected to increase even more (Fadelli and Fava, October 2021[42]). In

other words, public procurers are now given the necessary economic leverage necessary to influence infrastructure investments towards sustainability and environmental goals (OECD, 2021[39]).

While the use of public procurement for the specific purchase and implementation of NbS is still a novelty, the concept of Green Public Procurement (or GPP) is way more familiar to both public administrations and private contractors. The European Commission defines GPP as "*a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured*". (European Commission, 2008[43]). GPP constitutes an important tool to promote the use of greener products and services by public authorities and, therefore, to achieve environmental policy goals addressing climate change or biodiversity loss and supporting resource efficiency and sustainable production and consumption.

Even though there exist some clear differences between Green Public Procurement and the procurement of NbS[36], GPP's underlying principles and practices can actually promote the uptake of NbS by public administrations (Mačiulytė and Durieux, 2020[44]).

Green Public Procurement (GPP) in Italy

In Italy, the **2016 Code of Public Contracts**[37] sets out the procedure and norms for the procurement of public works, goods, and services. Moreover, it makes it mandatory for public contracting bodies to adopt green criteria in their purchasing choices. Italy is one of the few countries[38] across the globe where Green Public Procurement is binding at all levels of government. According to article 34 of the Code, all contracting authorities – whether at the national, regional, and local level, and regardless of the contract's value – must include the **Minimum Environmental Criteria** (MEC) in their public tenders, at least as technical specifications and contractual clauses. Paragraph 2 of the same article further requires considering MEC in the awarding stage of tenders for which the Most Economically Advantageous Tender (MEAT) criterion is applied.

A first **National Action Plan (or NAP) on GPP** was issued in 2008 by the Ministry of the Environment, together with the Ministry of Economy and Finance, the Ministry of Business and Made in Italy, and other national technical bodies (i.e. Consip, Enea, Ispra, Arpa). The NAP was later updated in 2013[39], and it is currently under revision (Ministero dell'Ambiente e della Sicurezza Energetica (MASE), n.d.[45]). The Plan represents the national reference framework on GPP and helps promote its implementation across the national territory. Most notably, it defines national targets to be attained and re-defined every 3 years and identifies the priority groups for intervention (Ministero dell'ambiente e della sicurezza energetica (MASE), 2013[46]).

The NAP is yet to be revised since 2017. In its current form, it is quite outdated in terms of environmental goals and ambitions, and it does not contain any references or targets specific to NbS. Advances in environmental standards and the recent country's commitments towards climate transition and green infrastructure would urge for refining the Plan to better leverage public procurement to achieve environmental objectives (i.e. halt biodiversity loss and restore ecosystem services) and improve ecological connectivity. Moreover, the absence of political commitment to complete the revision of the NAP is likely to make GPP implementation more challenging as it weakens public procurers' willingness and incentive to adopt green criteria.

The NAP also includes provisions for monitoring the GPP-uptake by the Italian public administrations and of the environmental benefits attained by green public purchases. Monitoring is key to identify bottlenecks in the existing frameworks and tools and develop appropriate corrective actions (i.e. training, awareness raising campaigns, workshops, etc.) and solutions to the dysfunctional elements (Ministero dell'Ambiente e della Sicurezza Energetica (MASE), n.d.[45]; OECD, 2015[47]).

While the 2016 Code mandates the National Anti-Corruption Authority (ANAC) to monitor GPP implementation, to date no report has yet been published. Instead, the reporting system in place suffers from several weaknesses. It mainly relies on an online survey to be filled in directly by the RUP (i.e. the Unique Responsible for the Procedure, *Responsabile Unico per il Procedimento*) of a given public tender, before 31 July every year. However, information gathered from the survey is relatively limited since it merely checks if MECs were included or not. Moreover, given the absence of public reports, the level of compliance by contracting authorities remains unknown. The absence of a sound monitoring system to check and, potentially, punish the non-compliers also runs the risk to further weakening public administrations' efforts to adopt GPP.

The existing weaknesses of the GPP monitoring system in Italy run the risk to hamper the potentials of public procurement to promote the widespread implementation of NbS by public administrations. As things stand today, it would be difficult to know how whether or not contracting authorities are purchasing nature-based solutions, how much and how well these NbS are actually performing. In the absence of such information, it is hard to intervene on the existing regulatory framework to improve it and make it more effective in promoting the procurement of NbS across the national territory.

To fulfil the monitoring vacuum, the *Osservatorio Appalti Verdi* (Green Public Tenders Observatory) – an initiative led by Legambiente and Fondazione Ecosistemi, with the support of other actors[40] - has been measuring the adoption of MEC by different contracting authorities since 2018. Every year, it publishes a report on GPP uptake in Italy. Results show that Italian Public Administration has improved its knowledge and practice of GPP over the last 4 years. However, MEC are still far from being fully implemented despite the existing legal obligation (Osservatorio Appalti Verdi, 2021[48]).

Minimum Environmental Criteria (MEC)

The NAP on GPP identifies the priority sectors for which MASE has to draft the MEC to be included in the different stages of the tendering procedure. These product/service categories are selected based on a multi-criteria analysis that considers different factors, including the volume of public expenditures (i.e. economic relevance), the scope of environmental improvement, as well as the market readiness to comply with green requirements (Hasanbeigi, Becqué and Springer, 2019[49]).

The NAP on GPP outlines the process for MEC development. The latter follows the EU Commission's process for EU GPP criteria, but it adapts to the specificities of the national production system. The criteria are mainly based on a market analysis of the sector, different reference sources suggested by the European Commission – i.e. EU GPP criteria, existing eco-label criteria, EU sectoral norms with an environmental character (Directive ERP, for example) -, as well as information collected from businesses and trade associations, consumers and users, and the public administration (Ministero dell'ambiente e della sicurezza energetica (MASE), 2021[50]).

The definition of MEC falls under the competence of the GPP Management Committee[41], which is coordinated by MASE. The Committee works together with technical working groups, representatives and experts of the public administration and central purchasing bodies, research institutes and universities, trade associations and economic operators. Once drafted, MEC are shared with other ministries, mainly the Ministry of Economy and Finance and the Ministry of Business and Made in Italy, to collect further comments and feedback. As a final step, MEC are adopted by means of a Decree by the MASE, which is published in the Official Gazette (Ministero dell'ambiente e della sicurezza energetica (MASE), 2021[50]).

MEC are defined for some or all the stages of the procurement procedure, including the subject matter of the contract, technical specifications, award criteria, and contractual clauses. Moreover, for each green criterion, information is also given on the appropriate means, documents, and mechanisms to verify compliance (Ministero dell'ambiente e della sicurezza energetica (MASE), 2021[50]).

To date, Italy has adopted MEC for 19 different categories of goods and services (see Table 4.4), some of which are currently under review (i.e. construction, management of waste and internal furniture). New MEC for other product and service categories are also expected to be defined in the coming future (Ministero dell'ambiente e della sicurezza energetica (MASE), 2021[50]). Each year, MASE shall set out an annual work plan to draft new MEC, as well as to review the existing ones. For the review process, MEC are periodically updated also considering the technological evolution and market developments for each product/service category.

Table 4.4. List of product/service categories for which MEC have been defined in Italy

Product category	Product/service description	Ministerial decree	Corrective decree	Updates
Textile products	Supply and rental of textile products (including filter masks, medical devices and personal protective equipment), and integrated collection, restyling and finishing service for textiles	11 January 2017	-	30 June 2021
Vehicles	Purchase, leasing, rental, and hire of road transport vehicles and public land transport services, special road passenger transport services.	8 May 2012	30 November 2012	17 June 2021
Cleaning for public buildings	Cleaning and sanitizing services for public buildings and supply of cleaning products.	24 May 2012	-	29 January 2021
Sanitization of healthcare facilities	Cleaning and sanitizing services for healthcare facilities (i.e. hospital, nursing homes, clinics, etc.) and supply of cleaning products.	18 October 2016		29 January 2021 w/ Corrective Decree of 24 September 2021
Industrial washing and rental of textiles and mattresses	Industrial washing services and rental of textiles and mattresses.	9 December 2020	-	-
Catering	Collective catering services and food supply.	10 March 2020	-	-
Public green	Creation and management of public green areas and supply of products for the management of green spaces.	13 December 2013	-	10 March 2020
Printer cartridges	Supply of toner cartridges and inkjet cartridges and integrated services for the collection of used cartridges, preparation for reuse, and supply of toner and inkjet cartridges.	17 October 2019	-	-
Printers	Managed printing services, rental services of printers and multifunctional office equipment, and purchase or leasing of printers and multifunctional office equipment.	17 October 2019	-	-
Indoor furniture	Supply and rental services for interior fittings.	11 January 2017	3 July 2019	23 June 2022
Working footwear and leather accessories	Supply of non-PPE and PPE work shoes, leather items, and accessories.	17 May 2018	-	-
Public lighting (service)	Public lighting service.	28 March 2018	-	-
Construction	Planning services and works for the construction, renovation, and maintenance of public buildings	11 October 2017	-	23 June 2022
Public lighting (supply and design)	Acquisition of light sources for public lighting, acquisition of public lighting equipment, entrustment of design services for public lighting systems	27 September 2017	-	-
Aids for incontinence	Supply of incontinence aids	24 December 2015	-	-
Urban furniture	Purchase of urban furniture	5 February 2015	-	-

Urban waste	Entrustment of urban waste management services (collection and transport), urban cleaning and street sweeping services, supply of containers and bags for urban waste, supply of vehicles and non-road mobile machineries for collection and transport of urban waste and for street sweeping	13 February 2014	-	23 June 2023
Paper	Purchase of copy and graphic paper	4 April 2013	-	-
Lighting, heating/cooling, or buildings	Energy services for buildings, lighting and motive power services, heating and/or cooling services	7 March 2012	-	-

Note: the product/service category description is based on the most recent ministerial decree issued by category.
Source: (Ministero dell'ambiente e della sicurezza energetica (MASE), 2021[50])

Among the new categories for which MEC are planned to be defined, there are also design and works services for new road constructions and road maintenance and public transport services. For the MEC to be revised, energy services for public buildings and urban furniture are pending.

To date, the **MEC for the creation and management of public green spaces** (Ministerial Decree of 10 March 2020) are the only example including specific requirements for the adoption of NbS. The corresponding Ministerial Decree specifies that every urban green element is part of the city's network of green infrastructures. For this network to be effective in providing ecosystem services, it is necessary to adopt solutions that mimic nature's criteria and rules, also known as nature-based solutions or NbS. Accordingly, the MEC provide a series of indications to guide the selection of plant species for the management of existing public green spaces (Ministero dell'ambiente e della tutela del territorio e del mare (MATTM), 10 Marzo 2020[51]):

- The pool of selected species should be consistent with the site, both in terms of flora and vegetation;
- Selected species should be autochthonous in order to safeguard nature conservation;
- Consider the changing climate conditions and pollution factors relevant for the geographic area under scrutiny;
- Assess the impacts of the selected species on human health as well as the risk of uncontrolled spread of the species;
- Select a pool of species belonging to plant associations consistent with the range of the site's potential vegetation and with the specific ecological conditions of the area;
- Select species with low water consumption, high resistance to environmental stress and phytopathologies, and with the best potential to activate autonomous capacity of organization towards more advanced forms of plant communities;
- Select tree species specific to the intended use.

Likewise, for the construction of new green areas, the MEC require to consider the following aspects for the selection of plant species (Ministero dell'ambiente e della tutela del territorio e del mare (MATTM), 10 Marzo 2020[51]):

- Adaptability to soil and climate conditions;
- Resistance to phytopathologies of any kind;
- Resistance to urban stress and heat island effect;
- The existence of obstacles or constraints to the future development of the selected plants;
- The presence of native or historicized vegetational species having an identity value for the local territory.

Except for this case, all other MEC do not include any specific requirements for NbS. Overall, MEC build upon a series of environmental principles that are likely to promote the purchase of NbS by public procurers, such as resource-efficiency, limited use of chemicals and hazardous substances, sustainable waste management, eco-design principles, recyclability, re-use of components, and so on (see Box 4.11) (Ministero della Transizione Ecologica (MiTE), June 2022[52]; Iyer-Raniga and Finamore, 2021[53]). However, more needs to be done to fully take advantage of MEC's and GPP's potential to support a systemic and widespread implementation of NbS in public investments. For example, the GPP Management Committee could develop and/or refine existing MEC to also take into account biodiversity conservation, restoration of ecosystem services and ecological networks. Product and service categories such as road construction and maintenance, public transportation, design and construction of public buildings and urban furniture seem to be a good place to start integrating considerations and requirements relevant for NbS.

Box 4.11. Genoa, Italy: procuring a new urban park through the implementation of MEC

Back in 2019, in the Gavoglio area, the local municipality of Genoa decided to use nature-based solutions to achieve three different objectives simultaneously:

- *Reconnecting the former barracks site with the neighbourhood*. This includes creating an urban landscape in accordance with the landscape of the area, ensuring better access to the park area, as well as creating connectivity to the sea;
- *Enhancing the urban nature capable of mitigating and adapting to the effects of the climate change*. This implies incorporating storm-water management elements, such as permeable surfaces, and planting lines of trees;
- *Creating inclusive and multifunctional public space*. This involves installing features that would allow access to all age groups, promote cohesion and enhance the sense of place for the surrounding neighbourhoods.

The objective of this public tender was to source a supplier who could redevelop the former military barracks area into an urban park, incorporating NbS. The project involved creating new green spaces, while ensuring their connectivity to the existing green infrastructure. It also aimed to include urban gardening elements as well as water management measures.

The public procurement of NBS was executed with an open tender procedure. Around 40% of the contract value was foreseen for the interventions containing greenery and urban furniture, in addition to construction, engineering and earthworks. The contract included all the works, services, and supplies necessary to redevelop the Gavoglio area. The special tender specifications listed the technical, qualitative and quantitative characteristics.

The criteria used

Environmental and sustainability considerations have been included in the special tender specifications. They refer to MECs for services and works for the new construction, renovation and maintenance of public buildings, purchase of the street furniture, lighting, and public lighting systems, as well as environmental criteria for the soil, and plants procured. The tender also included MEC requirements for the management of waste generated as a result of construction and "directly and/or indirectly generated by all the activities covered by the contract". In addition to MECs, compliance with ISO and UNI standards was required for construction materials.

While the technical specification document required the submitted offers to fulfil the MECs, the prevailing award criteria in this tender is the lowest cost. Additionally, the contractor is required to provide maintenance of green elements until the standard criteria-based approval test is performed by

the municipality. Upon the successful completion of the approval test, the city will take over the maintenance operations.

The environmental impact

The redevelopment initiative is aiming to address a wide range of environmental, including air pollution, the lack of public green spaces, water scarcity, heat stress, and biodiversity loss.

The project aims to preserve the surrounding historical and cultural heritage and the characteristics of landscape typical of the Liguria region. Different species of bushes and trees (including varieties of oak) could be found in the area before the start of the project. However, they were very poorly maintained. The city thus wants to preserve the existing native species by ensuring gradual thinning and adapting naturalistic forestry approach without unnecessary vegetation replacements. It expects to see a gradual recovery of the local ecosystem especially in terms of limiting pest control and invasive species. Additionally, multiple storm water management components installed in the park are expected to mitigate the risk of flooding and enhance local water supply.

Source: (Mačiulytė and Durieux, 2020[44])

4.6. Green infrastructure in transport planning in Italy

The process of transport infrastructure development in Italy is very articulated, with a strong hierarchy among the levels of governance. Effective processes require good co-ordination among different governance levels. This is primarily due to the territorial layout of the country of twenty regions consisting of numerous provinces (although the governance level at the provincial level has been abolished). Regional governments are involved in identifying areas for the construction of infrastructure and coordinating among a large number of local municipalities. Municipalities within provinces have their own transport development plans, e.g. Sustainable Urban Mobility Plans (SUMPs). State government plays a key role, but regions, metropolitan areas and municipalities may have different opinions of the planned works, and the state needs their consent to operate. Italy has developed a set of rules requiring the approval of the Conferenza dei Servizi, which gathers all relevant public and municipal entities for certain projects.

Sustainability is a priority in Italy for the government and transport infrastructure stakeholders. However, in the Italian transport sector, stakeholders perceive GI mainly as means to avoid and mitigate emissions and improve sustainability, and this differs from the GI definition used in this study. The country is highly committed to decarbonising the transport system and improving living conditions, e.g. by renewing bus fleets, stimulating a shift from private to public mobility, and electrification of rail and ports supported by PNRR. A good example is the Italian rail network, which today is Europe's most electrified rail network. Moreover, most of the policy measures implemented in the transport sector, such as the application of DNSH to transport projects, currently have a higher focus on mitigation and lacks closer connections with adaptation and biodiversity enabled by GI.

While mitigation measures are crucial for sustainable infrastructure development, climate adaptation goals should not be overlooked, as integrating the development of grey and green infrastructure can strengthen Italy’s resilience to the impact of climate change and bring benefits to the ecosystems. Moreover, the fragmentation of vast areas of the nature of the country’s rich landscape, including its effect on biodiversity, should not be overlooked.

In terms of infrastructure planning, once MIT prepares the strategy, individual projects are then integrated into this strategy. In the current practice, challenges exist in integrating existing transport infrastructures

into strategic plans to avoid conflicts. Oftentimes, it creates clashes with local governments and procedures in place and causes delays in implementation and issues with quality. A good example of a fund aimed at improving urban mobility is the National Operational Programme "Città Metropolitane" (NOP Metropolitan Cities). The goal is to improve the quality and efficiency of urban services and social inclusion for the more fragile population. The European Commission acknowledges it as good practice[42].

4.6.1. Sustainable railway planning in Italy

Regional differences exist in how the impacts of railway infrastructures are perceived in Italy, as revealed from the stakeholder interviews. In the south of the country, due to the high need for the work to be accomplished, the local administrations place more emphasis on economic development, thus putting more weight on the provision of the infrastructure. Nevertheless, the social and environmental impacts are also considered in the railway infrastructure development in the south of Italy, complying with European and national legislation. This could include riverbed restoration, underpasses, overpasses, etc. Additionally, National Operational Programme projects with a value of over EUR 60 million require extra investigation.

The assessment also includes mitigation measures for the impact of the railway infrastructure during and after the construction (operation), e.g. protecting habitats and emission levels during implementation and operation (e.g. construction sites). Construction sites for railway and road projects will usually be located in areas where they cause limited environmental impact.

4.6.2. Sustainable maritime planning in Italy

The Directorate-General for the Supervision of the Authorities of the port system, maritime transport and inland waterways at MIT is working on decarbonising the maritime sector, making the sector more sustainable, and complying with UN 2030 objectives. Several sustainable interventions in ports are being done, such as:

- Reforms to simplify procedures and improve and strengthen the infrastructure's resilience;
- Operational changes to simplify planning at the ports. This includes a strengthened role of regional port authorities and the Ministry;
- Implementation of special economic zones as part of PNRR;
- Strengthening of port management and port planning to improve the adoption of the Ministry’s guidelines;
- On-shore charging for vessels: EUR 700 million have been allocated for the construction of this intervention;
- Retrofitting of existing vessels: EUR 500 million have been allocated;
- Stimulating the wider use of LNG by building LNG plants: EUR 217 million have been allocated.
- Improved port-city area interactions to improve access to boats and vessels;
- Establishing an ad-hoc centre to support sustainability.
- Electrification measures are currently being developed. There is an ongoing discussion with the Italian association of ports (i.e. Assoporti) to understand their needs, as well as talks with vessel owners' associations. Then, the right calls for tender can be developed to make effective infrastructure development decisions.

4.6.3. Sustainable urban mobility planning in Italy

For urban mobility, the main objective at the national level is the transition to public transport in municipalities of more than 100 thousand inhabitants. This will result in a reduction in traffic, reduction in emissions, and improved quality of life. The central administration supports this transition. Regions are

responsible for investments and will involve the municipalities. Twelve billion euros have been allocated to the transition, of which 4.5 to renew bus systems. These state funds are allocated to regions and municipalities.

Compliance with existing laws is assessed in the framework of SUMPs. The Directorate-General for Local and Regional Public Transport and Sustainable Mobility monitors the implementation of SUMPs. MIT and MASE establish the guidelines of the SUMPs together.

Decisions for investments in regional transportation are made at state-regions conferences, which are a platform where political agreement is reached between state and regional governments. ANCI, the municipalities association, also takes part in these conferences.

In agreement with the regions and municipalities, green corridors and spaces could also be possibilities. These are currently not explicitly considered, although there are some examples of urban reforestation not specifically linked to GI and urban transport.

Italy has a well-developed knowledge base and planning structure for sustainable infrastructure and emissions mitigation. There is much emphasis on mitigating greenhouse gas emissions by avoiding and reducing them through several procedures ranging from governance and legislation to assessment mechanisms, such as environmental impact assessments and new assessment procedures initiated by MIT. The established and transparent procedure of assessment mechanisms could, in theory, offer opportunities to integrate GI into the transport planning process. However, there is no clear-cut definition of GI, and climate adaptation is not one of the main concerns in transport planning. Moreover, the benefits of GI are not fully and explicitly considered in the assessment methods. Therefore, more attention is needed for GI to make it an integral aspect of the transport planning process.

The technical and economic feasibility study (through CBA) and environmental impact assessment (EIA) are separate procedures without co-ordination or interaction. Ideally, the CBA would include the elements of EIA, and a comprehensive EIA should also have social and economic outcomes. Thus, ideally, both assessments should converge. For Italy, although NBS are considered in some aspects of EIA (e.g. soil, biodiversity, water), other impacts coming from implementing NbS should be more explicitly integrated as part of the evaluation criteria of the EIA, and national strategies to incorporate the GI and NbS need to be further encouraged. Furthermore, the consideration of GI integration should also be better reflected in the Strategic Environmental Assessments (SEA) at the programming level and the EIA at the project level, as advised by the European Commission.

Italy operates on several government levels, of which the main three are the state, the regions and the municipalities. Because of the large number of regions, provinces, Metropolitan Cities and municipalities, communication between all government levels is complex. In addition, GI is physically established in the local area, for which the contractors and the municipality must negotiate. This is a reason for concern, as the transport infrastructure still needs to be consistent with the strategic planning.

4.7. Railway line Palermo-Messina

4.7.1. Background

The Palermo-Messina railway is part of the Trans-European Transport Network (TEN-T). Palermo-Messina is a high-speed connection, and it is part of the subproject Berlin-Palermo of the Scandinavian-Mediterranean Corridor connecting Germany to the South of Italy, crossing through Austria. Moreover, with the possibility of extending from the mainland to Sicily by the Strait of Messina Bridge, the railway line could offer better connectivity of the South with the rest of Italy and support opportunities for the further economic development of the region.

Palermo-Messina is an existing connection in the Italian rail network. It will be substantially upgraded in the context of TEN-T. The main objective **is to speed up the current line** with an electrified double-track that allows 250 km/h speeds and complies with EU interoperability requirements. These upgrades and the necessary construction offer opportunities for further consideration of green infrastructure along the rail line.

This case study focuses on the Bicocca-Catenanuova section of the Palermo-Messina railway line, located in the eastern part of Sicily.

4.7.2. Reasons for planning this construction

The air connection between Catania Airport and Fiumicino Airport is currently very intensively used, with a large number of flights operating between the two cities. Besides, there is a lack of a rail connection between the two cities. Moreover, the existing line in Sicily is not up to the standards of pan-European rail corridors[43].

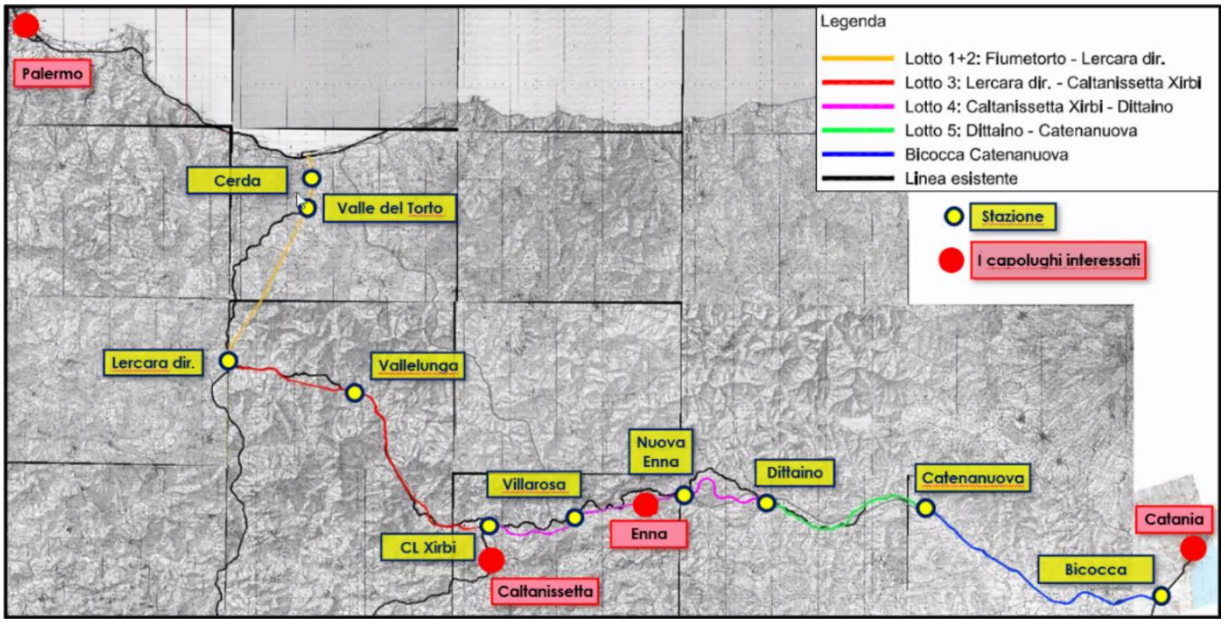
Milan-Rome used to be an air connection with comparable intensity, but since the opening of the high-speed rail line between them, it has become more popular to travel between the two cities by train. A similar mode shift could be expected with the improvement of the rail connection from Palermo, through Catania and Messina, to Rome. However, a gap in the connection between Messina and the mainland will remain since plans for the controversial Strait of Messina Bridge have been set aside over the past years. The rail connection will therefore have to rely on ferries for connection to the mainland.

The island of Sicily has three main cities: Messina, Catania and Palermo, and many medium-sized cities. Transport between these cities is mostly car-based as the existing railway is not competitive with car-based travel times. Moreover, many public and private transport services overlap with the train service. Rail is not an attractive, competitive mode due to the inconvenience of multiple interchanges needed. Frequent maintenance on highway segments often temporarily pushes a mode shift to rail but rebounds due to no direct train connections. For these reasons, the new rail connections need to be fast, connect the island's three cities and serve the towns in between. Therefore, high-speed rail was not a good option, but rather an upgraded railway with intermediary stops to guarantee accessibility to local communities, higher speeds and better connection times than the previous one.

4.7.3. Technical specifications

The Palermo-Catania railway upgrade is split into six sections, as shown in Figure 4.3. It is based on upgrades to the existing railway and also includes newly built sections.

Figure 4.3. Impression of the Palermo-Catania railway with its sections



Source: this figure has been taken from the documents RFI and MIT shared with the OECD

The upgrade of the 37 km-long track between Bicocca and Catenanuova consists of doubling the tracks (currently, only a single track is available and this causes delays) and upgrading the existing tracks to support higher speeds of up to 160 km/h. This will reduce the travel time between Catania and Palermo from about three hours to two hours. After completion of the project, the railway will use a signalling system compatible with ERTMS, thus complying with European standards and fit for integration into TEN-T. With the outlined upgrades, the section's capacity should increase to 150 trains per day, with the travel time decreasing from 25 to 17 minutes between Bicocca and Catenanuova.

According to the Independent Quality Review[44], the project consists of six elements:

1. Upgrading the existing track and constructing a second track for the entire length of the section;
2. Construction of two tunnels;
3. Construction of 17 viaducts;
4. Upgrading the station in Sferro and building a new station in Motta Sant'Anastasia;
5. Removal of three stops in the stations of Gerbini, Portiere Stella, and San Martino Piana;
6. Upgrading the Bicocca station.

Unused sections of the existing track will be removed. Such space will be given back to the community in the form of pedestrian and bicycle trails and will be used for the planting of trees.

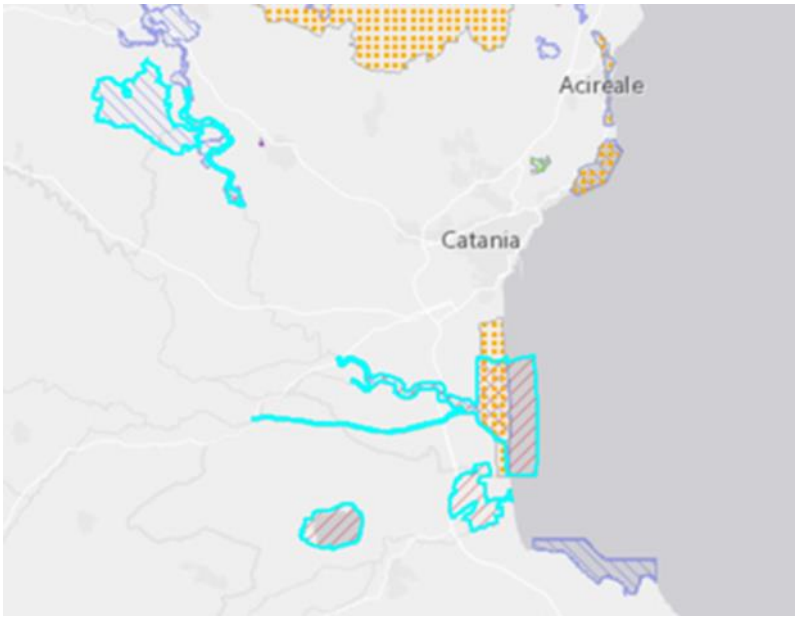
4.7.4. Planning process

The Palermo-Catania railway is financed by European and national funds. Sections 3 to 6 (including Bicocca-Catenanuova) are included in the PNRR and are thus subject to PNRR's environmental reporting requirements. Almost 30% of the financing of the Bicocca-Catenanuova section comes from European sources (ERDF and Resilience and Recovery Fund). RFI is the project's beneficiary and manages the infrastructure over its entire lifecycle.

The rail line does not cross any natural areas in Sicily, although it is in the proximity of several Natura 2000 areas (shown in Figure 4.4): Lago di Lentini is 1.9 kilometres away from the track; 2.7 kilometres from Foce del Fiume Simeto e Lago Gornalunga; 5.5 kilometres from Contrada Valanghe; 6.1 km from Tratto di

Pietralunga del Fiume Simeto. The environmental management plans of all these sites are integrated into the management plan for the Simeto river, which is crossed multiple times by the rail section. The Natura 2000 sites themselves, however, are crossed by neither the existing nor the newly planned sections, and the works comply with the criteria laid out in the Simeto management plan. However, these plans have not considered possibilities for connecting the sites by means of GI.

Figure 4.4. The Natura 2000 sites close to the Bicocca-Catenanuova section (highlighted in cyan)



Note: ITF/OECD analysis of "Natura 2000 End 2021 - European Environment Agency".
Source: (European Environment Agency (EEA), n.d.[54])

The Bicocca-Catenanuova section conforms to the National Operational Programme Infrastructure and Networks and National Transport Plan, for which SEAs have been carried out.

An EIA was carried out for the individual project. Some mitigation measures came forth from the EIA, mostly related to minimising construction impacts[45]. The costs of such mitigation measures were carried over to the CBA. Moreover, public participation was part of the EIA – in accordance with the European and national legislation.

Bicocca-Catenanuova is not a competitive railway structure when compared to other modes. The Ministry's primary objective was to accomplish the work of Bicocca-Catenanuova. For this project, there was little to none resistance by local communities, as they were not directly affected by the construction of the infrastructure. However, in some other cases, local communities might protest and ask for compensatory measures. According to law, compensatory measures should be related to the scope of the public works, but this is not always the case. For example, local municipalities might ask for the construction of a new school or for other solutions whose scope often goes beyond that of the specific project under scrutiny.

An environmental monitoring plan was also established, which includes plans to refurbish the areas of the removed existing tracks into bicycle and pedestrian areas with green spaces. The environmental monitoring plan includes indicators to monitor before, during, and after the construction phase, for the entire lifecycle of the work. The plan includes monitoring for potential future issues and existing issues. For example, during the creation of the environmental monitoring plan, issues such as water contamination were discovered. These have also been included in the environmental monitoring plan.

According to the independent quality review, several options analyses were carried out, but climate change adaptation was not considered. The environmental monitoring plan contains eight components, as summarised in Table 4.5.

Table 4.5. Monitoring components of the Bicocca-Catenanuova section

Component	Project phases
Surface water	Before, during, after construction
Groundwater	Before, during, after construction
Soil and subsoil	Before, during, after construction
Vegetation and flora	After construction
Fauna	Before, during, after construction
Air quality	Before, after construction
Noise	Before, during, after construction
Vibrations	Before, during, after construction

Source: this table was taken from the document RFI and MIT shared with OECD

A cost-benefit analysis (CBA) has been carried out in preparation for the project. In the CBA, two alternatives were compared: a zero-alternative (the existing rail line) and the upgraded line - as described in this case study. Judging from the Jaspers report[46], the CBA exclusively assessed the financial feasibility and did not include the potential monetisation of environmental benefits or costs associated with the project.

An Italian construction company has been working on the construction since the beginning of 2019, with close attention to the environment. In addition, an engineering company are performing remote sensing studies to monitor the impacts of excavation works carried out for building the infrastructure. The construction phase is part of the environmental monitoring plan, which was included in the EIA.

As stated before, the third part of the environmental monitoring plan includes the operational phase. Indicators monitored during this phase are air quality, surface and groundwater, soil, noise, vibrations, and biodiversity (flora and fauna).

4.7.5. Analysis of the integration of GI

The planned structure will include several GI elements:

- Unused sections of the existing track will be removed. This space will be given back to the community in the form of pedestrian and bicycle trails and for the planting of trees. Moreover, these infrastructures are connected to the existing cycling network in Sicily.
- Additional vegetation natural to the surrounding area will be planted alongside the infrastructure. This will happen in riverbeds, across intersections, and in small spaces between the tracks and a parallel road. The vegetation is limited to a small corridor next to the rail line and cannot interfere with, for example, existing agricultural land.
- During the ongoing construction phase, the environmental impacts of excavation works are strictly monitored.
- During the monitoring phase, multiple GI-related indicators, such as vegetation, soil quality and fauna are monitored.

It can be observed that GI have already been well-integrated into the project for aspects related to indicators and monitoring. However, these indicators fail to precisely reflect the purpose of GI, namely

limiting or reversing habitat fragmentation by connecting natural areas and thereby safeguarding and improving ecosystem services.

In addition to that, considerations of the spatial uptake of nature-based solutions remains limited. A railway line offers the opportunity to create green belts lateral to the ballast created with a mix of natural elements (trees, shrubs, grasses), contributing to the enrichment of ecological networks as secondary lines of connectivity. In the case of the Bicocca-Catenanuova track-doubling project, considering the phytoclimatic characteristics of the site, only localised interventions have been envisaged in certain areas (interconnected areas, residual areas following the decommissioning of roads or railways or due to the demolition of buildings, at the base of viaduct abutments,). For this reason, the project also includes measures to reduce the risk of ecological fragmentation by identifying elements of existing ecological networks to be upgraded and the appropriate measures to complete the 'design' of the ecological network to be created. For example, the banks of the Simeto river affected by the project will be the subject of an intervention to plant native shrub species consistent with the surrounding ecological environment and belonging to the potential vegetation series. More generally, interventions to upgrade the riparian vegetation are planned for all the crossings of the minor hydrographic network.

An international best practice where co-operation between public authorities and infrastructure managers such as RFI (ProRail in the Netherlands) work together to improve the integration of infrastructure and nature is stimulated, was the Dutch Green Deal *Infranature* initiative (also elaborated on as a planning initiative for GI in chapter 3). One of the projects under the initiative was an upgrade to a highway, with nature enhancement as one of the tender requirements. This forced contractors to come up with nature-inclusive designs and use the highway upgrade as a means to enhance nature and use the infrastructure as a connecting corridor.

4.7.6. Conclusions and recommendations

The construction of the Bicocca-Catenanuova section as part of the railway Palermo-Catania-Messina mainly aims to create a modal shift from road transport to rail and reduce greenhouse gas emissions. Green stations, biking paths and green areas are planned as part of the project, which will enhance the green dimensions of the infrastructure. However, these greening measures are not meant to integrate the railway with the surrounding nature. Green infrastructure was not explicitly studied in the planning and assessment of the line. This is understandable, as it was an existing line crossing through agricultural land, not natural areas. The Natura 2000 sites in the proximity are untouched by the infrastructure, but there is a missed opportunity to integrate GI into the project by using it to connect the surrounding natural areas.

Railway lines like these should be used as an opportunity to expand natural areas. A solid procedure for these considerations should be in place for similar projects in the future. Even though not essential in this case, standardising the integration of GI considerations into infrastructure planning could help protect the natural landscape in future instances in which it may be needed.

Some recommendations for improving the integration of GI into such types of projects are:

- GI should be integrated into the regional spatial planning. This would help ensure that infrastructure projects like the Palermo-Messina railway can offer an opportunity to connect natural areas that are fragmented by years of human development.
- More collaboration is needed between RFI and the local administrations: the territorial administration needs to be engaged in the project to allow for the greening of more natural areas besides narrow corridors.
- Environmental impacts should be included in the CBA. GI can create monetary benefits over time (e.g. through recreation), so integrating GI into CBA would be beneficial to fully consider its relevance, costs and benefits over the lifetime of an infrastructure project.

- The impacts of the infrastructure should be monitored with a stronger emphasis on GI. This can be done with more refined indicators reflecting the continuity of biodiversity, fragmentation of habitats, and total surface of natural areas around the infrastructure.

4.8. Metro line 4 in Milan

4.8.1. Background

Metro 4 is a new metro line in Milan that will cross the city east-west, from Linate Airport to San Cristoforo railway station. The line connects to the existing metro lines 1, 2 and 3 at San Babila, Sant'Ambrogio, and Missori (Sforza-Policlinico for line 4), respectively. The metro line ensures a good connection between Linate Airport and the city. Metro 4 will be 15 kilometres long with 21 stations and pass through the historic city centre of Milan.

The metro line is now partly in construction and partly in operation. The first phase of the metro line is already operating, and the subsequent phases will become operational over the course of the following years until 2024. Once completed, M4 should be able to serve 24 000 passengers per hour. This offers an excellent opportunity to shift travellers from more polluting private modes to public transport, thus reducing GHG emissions.

4.8.2. Reasons for planning this construction

The metro line can serve as a mean to stimulate a transition from private mobility to public mobility, which is the main objective for urban transport on the national level. The national administration plans to achieve a transition to public transport in municipalities with more than 100 000 inhabitants. This will lead to reduced traffic, and therefore reduced emissions and improved quality of life.

The planned metro line specifically contributes to these objectives because it crosses major centres of interest in the city. With Linate Airport on one end of the line, San Cristoforo station on the other end, and crossing the city centre of Milan, it crosses the city east/south-west and offers connections between the entire urban area of Milan to international destinations. Furthermore, the metro line offers additional transport options along important transport corridors in the city, e.g. Lorenteggio-Foppa and Forlanini-Argonne. It also provides a partial alternative to the Bisceglie branch of metro line 1 (Comune di Milano, Consorzio MM 4, SPV M4, 2012[55]).

According to Webuild, the metro line could reduce the daily number of car trips in the metropolitan area by 180 000, bringing a CO2 reduction of 75 000 tonnes annually (Webuild, n.d.[56]). The Environmental Feasibility Study mentions different numbers: a reduction of 3.69 million car trips per year (10 000 daily), saving 10 310 tonnes CO2, 18 052 kg Nox and 1 511 kg PM10 annually. It is expected that 86 million trips will be made using this metro line every year.

4.8.3. Technical specifications

The metro line will have a length of 15 kilometres and run entirely underground (except for the depot area), consisting of two single-track tunnels. The metro line will be fully electrified and operated by an automated, driverless system with automatic platform doors. The fleet will consist of 47 vehicles, which can run at a maximum speed of 80 kilometres per hour. In some sections that pass under the city centre, the maximum will be 50 kilometres per hour. The line will be able to transport 24 000 passengers per hour in each direction with a frequency of one train every 90 seconds (Comune di Milano, Consorzio MM4, SPV M4, 2012[57]).

The work consists of three sections: one section from San Cristoforo to Sforza/Policlinico (6.5 kilometres with 13 stations), the other from Sforza/Policlinico to Forlanini train station (4.2 kilometres including 5 stations), and the last from Forlanini to Linate Airport (the so-called EXPO-route, 3.5 kilometres with 3 stations). The entire route can be seen in Figure 4.5. As is clear from this map, the line offers several connections to the existing transport system in Milan. From west to east, these are the following:

- San Cristoforo FS: connection to train line S9 (suburban rail)
- Sant'Ambrogio: connection to metro line 2
- Sforza-Policlinico: connection to metro line 3 (on which the station is called Missori)
- San Babila: connection to metro line 1
- Dateo: connections to train lines S1, S2, S5, S6, and S13 (suburban commuter rail lines)
- Forlanini: connections to lines S5, S6, and S9 (suburban commuter rail lines)
- Linate Airport: connections to (inter)national destinations

Figure 4.5. M4 route

Note: impression of Metro Line 4 and its position in the metro network of Milan
Source: (Comune di Milano, Consorzio MM4, SPV M4, 2012[57])

4.8.4. Planning process

Milan's metro line 4 is part of the wider mobility strategy: the city's Sustainable Urban Mobility Plan (SUMP), which is seen as a best practice in Italy. Milan's SUMP is a strategic planning tool aiming to provide a mobility plan to accommodate transport demand in the metropolitan area. The SUMP is part of the national strategy for sustainable transport, intending to reduce emissions and improve quality of life by transitioning from private to public mobility and fleet renewal to zero-emissions technology (e.g. EUR 4.5 billion have been allocated to bus fleet renewal).

Milan's latest SUMP was approved by the Council of the Metropolitan City of Milan in April 2021. A SEA was part of the creation of the plan (Citta' Metropolitana di Milano, April 2021[58]). The central government defines the objectives, regional authorities are responsible for how the funding is invested, and municipal governments execute the plans.

The compliance of mobility plans and projects with existing laws is assessed in the framework of SUMPs. The guidelines for SUMPs are finalised by MIT and MITE, with a monitoring committee consisting of representatives from the relevant institutions, including the regions. Investments in regional transportation are agreed upon at state-regions conferences, a venue where political approval is reached between the state, regional governments, and ANCI (the municipalities association). The MIT Directorate for Local and Regional Public Transport and Sustainable Mobility then monitors the implementation of the SUMPs. If there are any assessments related to adaptation to be performed, they should be part of the SEA that is carried out when finalising the SUMP.

In the regional context, three plans are relevant to the metropolitan area's opportunities to integrate GI.

- First, there is the Territorial Plan of the Province of Milan (PTCP), which includes guidelines for spatial planning in the province. The plan includes objectives that are highly relevant when considering GI. One objective states that all transformations in the territory should be assessed against the quantity and quality of natural resources (air, water, soil, vegetation) and should protect and enhance the landscape. Another objective concerns the reconstruction of the province's ecological network, biodiversity, and the creation of ecological corridors. Finally, there are two objectives related to limiting urban sprawl and increasing the quality of life in the city through increasing public areas, particularly green areas, and environmental regeneration (Comune di Milano, Consorzio MM 4, SPV M4, 2012[55]).
- The other highly relevant plan, especially for metro line 4, is the Regional Plan of the South Milan Agricultural Park (PRTA). This plan concerns a regional metropolitan green belt park, integrating agricultural areas with natural green spaces and providing green connections between the city and the countryside. It also includes an identification of areas that must be protected to preserve the landscape. Any plans under the PRTA that significantly impact the objectives as laid out in the PTCP should also be approved by the regional authority. San Cristoforo and Forlanini Park, both stops on the metro line, are part of this PRTA.
- The last regional plan related to GI is the Forestry Master Plan of the Province of Milan (PIF). This plan includes a mapping of all woods and areas with trees in the province and gives guidance on the further development and management of these wooded areas.

The initial project was approved in two phases. The preliminary project for Lorenteggio to Sforza/ Policlinico was approved in August 2007, while the preliminary project from Sforza/Policlinico to Linate was approved in August 2008. The final project was then drawn up in 2013. Therefore, the environmental feasibility study (2010) also included an elaboration on the Analysis of Environmental Problems for the Lorenteggio-Sforza/Policlinico section and the Environmental Prefeasibility Study for the Sforza/Policlinico-Linate section. The study concludes several significant environmental impacts, especially during the construction phase, even though the metro line is, naturally, built underground. The main impacts identified in the study were:

- Land occupation by construction sites – to be restored after the construction phase;
- Impact on roads and traffic flow – changes in the layout of roads by the occupation of construction sites could lead to the generation of heavy traffic conditions;
- Changes to the urban and peri-urban landscape;
- Production of dust and local pollutants by construction activities;
- Noise during both construction and operation (during operation, mostly related to ventilation systems);
- Vibrations during the construction phase;
- Spread of invasive species induced by construction activities;
- Impact on the enjoyment of spaces by the city's inhabitants – notably mainly related to public green spaces that would be affected by the construction works.

Two main mitigation measures were proposed to mitigate the abovementioned impacts. The first measure was reducing the construction time by applying appropriate construction techniques and efficient planning. The second measure was to limit the surface taken up by construction sites and use these spaces as efficiently as possible. Therefore, two main construction sites were assigned to the project, both in the peripheral areas of Milan (Comune di Milano, Consorzio MM4, SPV M4, 2012[57]).

Moreover, there are several mitigation measures geared towards specific environmental impacts. Physical barriers will be installed to combat dust generation, and construction roads will be wetted to prevent dust from being stirred up by vehicles. To mitigate noise by excavations, soil movement and production of construction materials, three measures were taken: installation of physical barriers, scheduling the works during the daytime, moving noise sources away from inhabitants and the use of equipment with up-to-date maintenance. Regarding impacts on soil, several measures were introduced: metal containers for the collection of waste, dedicated areas for the storage of waste materials, and environmental management of potentially polluting/contaminating activities (avoiding refuelling of vehicles within the construction site, immediate removal of oil, grease, and hydrocarbons spilling). The General Report for the Final Design does not mention mitigation measures to be taken that could limit environmental impacts during the project's operational phase. Moreover, it does not mention measures related to green infrastructure integration.

As part of the work, an environmental monitoring plan has been established. The plan includes prescriptions for the methodology, regulation, sampling frequency and times, and locations where the following indicators should be monitored: noise, atmosphere (local pollutants), vibrations, traffic and viability, groundwater environment, and vegetation (Comune di Milano, Consorzio MM4, SPV M4, 2012[59]). A separate report has been published to detail the monitoring plan for each of these indicators. The General Report mentions an Environmental Management System with guidelines for controlling and monitoring environmental impacts during the construction phase. The Environmental Monitoring Plan itself mentions that during the operational phase, only the noise, vibration and vegetation components will be monitored by the infrastructure manager. All measurements will be compared to the initial state of the environment, as defined by measurements before any construction takes place (ante operam).

4.8.5. Analysis of the integration of GI

The Metropolitan Area of Milan is the largest one in Europe and stretches from Como in the North to Pavia in the South and from Novara in the West to Bergamo in the east. This area contains several Natura 2000 sites and other protected areas. However, metro line 4 does not pass remotely close to any of these areas, thus will not damage any of them, nor will it be able to offer opportunities for connecting them. Milan has urban woods, such as Boscoincittà, located to the west of the city. In the Metropolitan City of Milan, green spaces such as parks, forests and wetlands take up 11.9% of the surface, much higher than average for provincial capitals (Hansen et al., 2015[60]).

Metro line 4 does not seem to cross any of these large green areas; moreover, it would run underneath them if this had been the case. However, this means that areas around stations will not offer an opportunity to connect large green areas to each other. The orientation of the metro could offer some opportunity for small green corridors inside the city, which would be beneficial for adaptation to climate risk. However, the metro line has not been specifically designed to do so. Impact on its surroundings during construction may be mitigated, but from the OECD's analysis, it is not clearly concluded that any opportunities for adaptation have been taken into account.

The Forlanini stop connects to suburban rail lines and is an important node on the metro line. The route of the metro line close to this stop was adjusted to avoid affecting traffic conditions on Viale Forlanini, the main road to Linate Airport on the east side of the city. Instead, construction areas' locations were shifted to affect some areas of Forlanini Park during the construction phase. While this was a sensible decision regarding traffic flow, it remains disputable whether this was the right decision concerning green

infrastructure. While the General Report states that pre-existing structures such as trees have been preserved as much as possible, it does not clearly state to which extent natural elements were affected, not to mention the use of the project to further enhance the natural elements in the park. The stations of the Forlanini stops will only marginally impact the park (Comune di Milano, Consorzio MM 4, SPV M4, 2012[55]).

On the other side of the line, around Via Lorenteggio (a major road leading into the inner city of Milan), between the stations of Segneri and Gelsomini, notable efforts have been planned to use the project for greening the urban area. This is also the case for a small area in the east side of Milan, around Corso Indipendenza, Corso Plebisciti and Viale Argonne. These all consider urban areas with a more spacious configuration and linearly aligned buildings and roads that easily allow for the enhancement and addition of greenery along those areas. Interestingly, the Via Argonne Area is located several hundreds of metres away from the area that the metro line passes underneath. The plan for these areas is to create extended bicycle and pedestrian areas that include the implementation of green areas. The General Report mentions these redevelopment projects being a part of the concept of an ecological corridor, unifying separate parks into one green area.

Additionally, there are GI-related plans for the stations of Frattini, San Babila, Datea, and Tricolore. These stations are part of a public space redevelopment, including bicycle paths, pedestrian areas and paths, and the development and addition of green areas. Moreover, a quarry lake near the San Cristoforo station will be redeveloped as part of the project (Comune di Milano, Consorzio MM 4, SPV M4, 2012[55]).

Thus, a large part of the metro line has been integrated with plans for green elements, either around stations or in other nearby areas. However, for the portion of the line between Tolstoi and Sforza/Policlinico, passing through the inner city and including 9 stations and a significant portion of the length of the line, there are no plans for the inclusion of GI. This is defendable, as the metro line passes under the dense urban fabric that does not easily allow for larger green or ecological corridors. However, these areas are important to consider when considering green infrastructure and adaptation measures. Furthermore, these dense urban areas are particularly vulnerable to the effects of climate change and extreme weather events due to their high population density and often limited capacity for rainwater drainage.

4.8.6. Conclusions and recommendations

The construction of metro line 4 in Milan is part of the wider Italian strategy to create a modal shift from private to public transport. It can assist in establishing that shift, and therefore not only reduce CO2 emissions but also improve traffic conditions in the city. The line crosses through the city from the southwest to the southeast, including a part located in the inner city of Milan. The line is almost completely underground and thus has limited environmental impacts in the city during the operational phase. Therefore, the environmental assessment and environmental monitoring plan have been mostly focused on mitigating and monitoring environmental impacts during the construction phase.

The line does include elements of green infrastructure. For example, the parts of the line outside the ring road of Milan are accompanied by urban redevelopment projects, adding pedestrian areas, bicycle paths, and enhancement and connection of green areas. This corresponds well with the wider green planning context of Lombardy and the Metropolitan City of Milan, which includes plans for environmental regeneration, increasing quality of life and the possibility for public spaces by reducing car traffic. This case can, for its actions on urban green spaces and its connections to natural areas outside of the inner city, been seen as a national and even international best practice for GI inclusion in urban transport infrastructure. However, there are still some improvements that could be undertaken to provide an even better integration of GI. Notably, in the inner city, which is particularly vulnerable to the effects of climate change, no plans for GI have been found in the literature review conducted for this case study. Moreover, the GI plans that are part of the infrastructure project are not fully connected areas and concern more separate patches of green elements. This is perfectly understandable given Milan's dense urban fabric and

is often seen in cases of other cities, too (e.g. Lisbon, where green corridors and urban regeneration projects are located mostly outside of the densest inner-city areas). However, if Milan could improve some of the aspects even more, it could be developed as a major hub and exemplary urban area for green infrastructure.

Some recommendations for improving the integration of GI into this type of project are:

- More co-ordination is needed between regional and local authorities on how to include GI when planning how to spend funding for centrally planned sustainable mobility and executing plans for modal shifts. This would help establish a modal shift within cities and protect the city from the harmful effects of climate change and extreme weather events.
- Climate change adaptation, green infrastructure, and nature-based solutions should become part of SUMPs, so they can be properly assessed in the SEA that is performed for each SUMP. This ensures that long-term benefits of GI would also be properly considered and assessed in the SEA if they are integrated into the SUMP.
- Although a metro line is completely underground, the operational phase should be more explicitly considered in the environmental impact study, with more emphasis on the infrastructure's capacity to adapt to climate change. This could even promote GI projects such as Milan's M4 – a full assessment of environmental impacts, including positive impacts, would show that a project such as this one, with urban greenery integrated into the project scope, offers long-term environmental benefits.

4.9. Green infrastructure and NbS for urban planning in Italy

In Italy, over 70% of the total population lives in urban areas – and this figure is projected to grow to over 80% by 2050 (CCMC, 2021[61]) (Fondazione per lo Sviluppo Sostenibile, n.d.[62]). Climate impacts are particularly acute in urban areas, as Italy displays one of the highest percentages of sealed surface (i.e. 7.1%) in the EU (Di Pirro et al., 2022[63]). This, combined with highly fragmented urban-wildland interfaces, challenges the connectivity across green spaces (Di Pirro et al., 2022[63]) and exposes the urban population to a higher risk of flooding and to extreme heat. In southern regions, in particular, heatwaves pose increasing challenges during the warm summer months. Under climate change, both average temperatures and the frequency and duration of heat extremes are projected to grow substantially in the coming decades, with heatwaves becoming 35% more frequent under a 2°C warming scenario and 80% more frequent under a 4°C scenario (CCMC, 2021[61]). Due to climate change, in recent years, the region of Puglia reported significant heat extremes and climate-related hazards, which have been characterised by higher-than-usual frequency and duration (Climate ADAPT, 2014[64]). Under climate warming, impacts caused by warmer and drier conditions in the region are only expected to increase (Climate ADAPT, 2014[64]).

An increasing number of Italian cities is using urban regeneration as a way to enhance the environmental and climate sustainability of urban areas. For example, the City of Bologna has undertaken a project to green the inner urban area and enhance its adaptation to climate change (Climate ADAPT, 2016[65]). In the City of Milan, the regeneration of the Porta Nuova district – one of the largest urban regeneration projects in Europe – has transformed a former industrial and railway area into a pedestrian green neighbourhood, which now includes two "vertical forest" skyscrapers and Milan's third largest park (the "Tree Library", i.e. "*Biblioteca degli Alberi*"). Several green roof projects are also being developed in the city (Clever Cities, 2021[66]). The City of Torino is also heavily experimenting with various GI and NbS projects including community gardens, urban farms, green roofs and walls (Oppla, n.d.[67]) (ProGIreg, n.d.[68]).

The development of green infrastructures in Italy relies on the favourable conditions produced by the extensive work already done on ecological networks (*reti ecologiche*) – which include the Natura 2000 sites, parks and other protected natural areas – as well as by the innovative initiatives developed by many regions, provinces and municipalities to protect and enhance the assets of their respective territories (Fondazione per lo Sviluppo Sostenibile, n.d.[62]). Ecological networks are present in almost all Italian Provinces, scattered throughout a high number of municipalities (Fondazione per lo Sviluppo Sostenibile, n.d.[62]). The development of urban green infrastructures is also the object of various regulatory instruments, which include the "Norms for the development of urban green areas", the "Guidelines for the management of urban green areas", and the Minimum Environmental Criteria (MEC, see Section *Minimum Environmental Criteria* above) on the management of urban green areas.

A key instrument to support urban regeneration in Italy is the *Programma Innovativo Nazionale per la Qualità dell'Abitare* (PINQuA). The programme – which falls under the responsibility of the Italian Ministry of Infrastructure and Transport (MIT) – is an innovative national tool through which funds are made available to regions, municipalities as well metropolitan cities to redevelop and enhance the quality of housing, as well as of broader urban areas (BibLusBIM, 2021[69]). Overall, PINQuA prioritises the redevelopment of social housing, the renovation and regeneration of urban quality, the improvement of urban areas' accessibility and safety, as well as the reduction of housing shortages and the increase in environmental quality. At the same time, PINQuA focuses on public housing interventions with a high strategic impact on the national territory (BibLusBIM, 2021[69]).

In the context of Italy's post-Covid recovery and resilience plan (i.e. the PNRR), PINQuA has been scaled up to support the 14 Italian metropolitan cities to become more liveable and greener (Governo Italiano, 2021[25]). Indeed, these cities are increasingly exposed to social and environmental challenges such as air pollution, climate change impacts, as well as housing deficit and inequality, with serious consequences on the well-being and health of citizens (i.e. almost 21 million people). Overall, PNRR funding – which allocates 37.5% of its funds to the achievement of climate and environmental goals – aims to contribute to solve these challenges – addressing urban issues such as biodiversity loss, low air quality, excessive soil use, and growing climate risks through the creation of new green spaces (European Commission, 2022[70]). Altogether, these funds aim to improve the liveability of urban areas, enhancing their accessibility, functionality, safety, and environmental sustainability.

The Nodo Verde is one of the 159 projects approved to receive PNRR funding, and one of the 8 flagged as excellence pilot projects (i.e. *"progetti pilota ad alto rendimento*") under PINQuA (BibLusBIM, 2021[69]; Ministero delle infrastrutture e dei trasporti (MIT), 2021[71]). The projects have been presented by regional and local authorities – in the case of the Nodo Verde, by the municipality of Bari – and selected by a dedicated cross-ministerial Commission.

Box 4.12. GI and NbS for urban flooding control

Flooding from heavy precipitation is frequent in Italian cities, due to the exceptionally high percentage of sealed and impermeable surfaces (CMCC, 2021[72]), which prevent water from infiltrating in the soil thus increasing water run-off and urban flooding risk. To date, 9 out of 10 Italian municipalities are subject to medium flooding risk, while 10% of the national population is exposed to high flooding risk (CMCC, 2021[72]). Areas affected by water run-off are expected to grow between 6% and 10% in the coming decades[47] (CMCC, 2021[72]), while by the end of the century flooding impacts are expected to reach up to EUR 9.6 billion every year under a +4°C warming scenario (CMCC, 2021[72]). Globally, urban property damage from flooding alone costs around USD 120 billion every year (OECD, 2020[73]).

Urban GI and NbS such as permeable pavements, green roofs, urban parks and water retention areas (e.g. rain gardens, bioswales, and artificial wetlands) can manage excess water and reduce the risk of

urban flooding through enhanced water retention and natural drainage services. These measures are most effective when combined among themselves or with grey infrastructure (Ozment, Ellison and Jongman, n.d.[74]). Overall, GI and NbS for flood protection are estimated to provide benefits 6 to 8 times larger than their development costs (Trinomics, ALTERRA, Arcadis, Risk & Policy Analysis, STELLA Consulting, and Regional Environment Center, 2016[75]). For example, green roofs alone have the potential to retain 50-100% of all excess precipitation in urban areas (Ozment, Ellison and Jongman, n.d.[74]). Their higher initial cost (as compared to traditional roofs) is usually compensated by a longer lifespan as well as by the co-benefits they entail in terms of building insulation and sewage overflow prevention (Ozment, Ellison and Jongman, n.d.[74]). Similarly, permeable pavements can reduce up to 90% of run-off volumes in urban areas (Ozment, Ellison and Jongman, n.d.[74])by transferring water to urban green spaces or other areas. Urban parks and green areas can also help reduce flood risk while at the same time promoting water retention for future use. For example, green spaces in Beijing are estimated to capture over 150 million m3 of excess water (Ozment, Ellison and Jongman, n.d.[74]). Urban water retention areas, such as bioswales and rain gardens (i.e. vegetated trenches), can also be designed to retain water run-off in strategic locations, while at the same time filtering water pollution. Indeed, these interventions alone are estimated to be able to remove up to 90% of heavy metal-pollution from excess water (Ozment, Ellison and Jongman, n.d.[74]). Finally, artificial urban wetlands can also store large amounts of water, reducing run-off risk as well as peak water loads on urban water management infrastructure. For example, less than a hectare of wetland is estimated to retain between 7.6 and 11.4 million litres of excess water (Ozment, Ellison and Jongman, n.d.[74]).

Thanks to these observed benefits, several cities are scaling up urban GI and NbS for flooding management. For example, the city of Malmo (Sweden) uses rain gardens as the primary infrastructure for urban drainage (Frantzeskaki and McPhearson, 2022[76]). In China, the Sponge City Initiative aims at turning 80% of the country's urban areas into permeable surfaces, reducing flooding risk while also enhancing water quality and conservation efforts (World Bank, 2021[77]). Similarly, through its Cloudburst Management Plan, the city of Copenhagen is also investing in GI and NbS for water retention and drainage to complement the traditional sewage system and cope with the impacts of extreme rainfall (Climate ADAPT, 2022[78])

Source: (Climate ADAPT, 2022[78]; Ozment, Ellison and Jongman, n.d.[74]; OECD, 2020[73]; Frantzeskaki and McPhearson, 2022[76]; World Bank, 2021[77]; Trinomics, ALTERRA, Arcadis, Risk & Policy Analysis, STELLA Consulting, and Regional Environment Center, 2016[75]; CMCC, 2021[72])

Box 4.13. GI and NbS to combat the heat urban island effect

Heatwaves are increasingly frequent on the Italian territory. Under climate change, both average temperatures and the frequency and duration of heat extremes are projected to grow substantially in the coming decades, with heatwaves becoming 35% more frequent under a 2°C warming scenario and 80% more frequent under a 4°C scenario (CMCC, 2021[72]). The dense concentration of buildings, roads and sealed surfaces makes cities particularly prone to heat stress, as artificial landscapes (and especially materials such as concrete, metal, and cement) absorb and re-emit more radiation than do natural environments. This, combined with high pollution concentrations and the many urban activities generating heat (e.g. vehicles, industrial areas, air-conditioning systems, etc.), often gives rise to the so-called urban heat island (UHI) effect, a phenomenon for which urban areas experience higher temperatures than their neighbouring areas. In Italy, large urban areas are often subject to temperatures 1 to 3°C higher than those recorded in outlying areas (Istituto nazionale di statistica (ISTAT), 2022[79])

The UHI effect has particularly severe impacts in large and heavily-developed urban agglomerations, as proven by the high mortality toll observed during recent heatwaves in Rome, Milan and Turin (CMCC, 2021[72]; Istituto nazionale di statistica (ISTAT), 2022[79])

Thanks to their ability to regulate local temperatures, GI and NbS represent one of the key tools to address UHI in urban areas, regulating temperature both in open spaces and inside buildings. Green urban areas such as parks, water basins, green roofs and green walls can contribute to cool down surface temperatures, create shadow and increase air moisture (Istituto nazionale di statistica (ISTAT), 2022[79]). Green roofs and walls also contribute to cool buildings and structures, thus indirectly also reducing energy needs and air conditioning-induced heat (Frantzeskaki and McPhearson, 2022[76]). In the city of Hangzhou (China), the use of green roofs alone has been associated to a reduction in air temperature of 1°C. Similar temperature reductions were associated with the use of permeable bricks and concrete in the city of Guangzhou (CodeBlue, 2022[80]).

Source: (CMCC, 2021[72]; Frantzeskaki and McPhearson, 2022[76]; Istituto nazionale di statistica (ISTAT), 2022[79]; CodeBlue, 2022[80])

4.10. The Nodo Verde project: Fostering urban green solutions in the city of Bari

4.10.1. Project context and objectives

The Nodo Verde project aims at the redevelopment of an urban area of almost 160 thousand square meters in the city of Bari, the capital city of Apulia region in southern Italy. By creating a wide pedestrian passage above the railway line, Nodo Verde aims at greening and repurposing the railway station area, while at the same time reconnecting four neighbourhoods that have long been divided by the railway line (i.e. the city centre, Carrassi, San Pasquale, Madonnella) (see Figure 4.6). The project, to be implemented by 2026, entails the development of an artificial hill, or green roof, above the railway station, as well as the creation of two new public parks west of the station, i.e. between the station and Via Quintino Sella (Comune di Bari, 2021[81]). The project also entails the rehabilitation and repurposing of the main square in front of the station and of the disused Caserma Rossani buildings. Overall, Nodo Verde will substantially increase the amount and connectivity of green areas within the city of Bari, creating a green corridor of 2.2 km throughout the city that will include previously existing urban green areas such as the 3-hectare Parco Rossani, Piazza Aldo Moro, and Piazza Umberto (Figure 4.7). The project will also provide new options for urban mobility through the development of new areas for pedestrian and bike mobility and the enhancement of existing railway and public transport connections. Finally, the project entails the development of a community centre, which will be developed in the spaces of the abandoned Caserma Rossani (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]) (RFI - Direzione Stazioni, 2022[83]).

Figure 4.6. The Nodo Verde's project area

Source: (RFI, 2022[84])

The project aims to generate several benefits simultaneously. By renovating and reconnecting different neighbourhoods of the city, Nodo Verde will improve the liveability of the area and increase the value of neighbouring buildings, providing citizens and travellers with a new recreation area. Besides, the project will contribute to augmenting green spaces that will harbour urban biodiversity and improve air quality (RFI, 2022[85]). Besides, the new green areas will play a key role in reducing the urban heat island (UHI) effect and will contribute to manage excess rainwater and flood risk (RFI, 2022[85]). Addressing these issues is critical as, in recent years, the Apulia region has already suffered significant climate-related hazards, such as severe heatwaves and drought episodes, which are only expected to increase going forward (Climate ADAPT, 2014[64]).

Increasing green public spaces is particularly crucial in the metropolitan area of Bari. Indeed, various human wellbeing indicators in Bari are significantly below the national average (Città Metropolitana di Bari, 2022[86]). For example, in 2019, the amount of urban green space per capita in the metropolitan city of Bari was 9.2 square metres, as compared to an average national value of 33.9 square metres (BES delle Province, 2021[87]). Similarly, in 2019, the ratio of urban parks over the overall developed surface was 0.2% in the metropolitan city of Bari, as compared to a national average of 1.8% (BES delle Province, 2021[87])[48].

Figure 4.7. Nodo Verde's project plan: before and after

Note: The first figure is an aerial photo highlighting existing green spaces in axis with the Bari Central Station. The second figure shows a project render of Nodo Verde.
Source: (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]; RFI, 2022[85])

4.10.2. Institutional roles and setup

The Nodo Verde project relies on the collaboration of several stakeholders at different levels of government, as well as from the private sector. Collaboration between the **Ministry of Infrastructure and Transport** and the **Municipality of Bari** has been central to this project since 2004, when the two entities signed a memorandum of understanding (*Protocollo di Intesa*) on the redevelopment of the urban areas adjacent to the railway station and to the port (RFI - Direzione Stazioni, 2022[83]). As the urban redevelopment plans took shape, the **Apulia Region, the Metropolitan City of Bari,** and various **transport stakeholders** have been involved in the development of the project (RFI - Direzione Stazioni, 2022[83]). In 2014, an international project idea competition was launched and the Nodo Verde – presented by the architectural firm **Studio Fuksas** – was selected as the winning proposal (RFI - Direzione Stazioni, 2022[83]). In 2021, a new memorandum of understanding "for the infrastructural enhancement of the Bari railway node and the urban regeneration of the areas railway areas" was signed by the City of Bari, the Apulia Region and a number of transport stakeholders, including Rete Ferroviaria Italiana (RFI), Ferrovie dello Stato Italiane (FSI), FS Sistemi Urbani, and GS Rail (RFI - Direzione Stazioni, 2022[83]), marking the start of the project.

In 2021, the Municipality of Bari submitted the project proposal to the Ministry of Infrastructure and Transport, to apply for **PNRR** funding under the *Programma Innovativo Nazionale per la Qualità Dell'Abitare* (**PINQuA**). Nodo Verde was then selected to be funded as one of the urban regeneration projects (under the PNRR's Programme on "Southern urban hubs for the development of sustainable mobility", i.e. *Hub urbani del Sud per lo sviluppo della mobilità sostenibile*) (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]) (Press Regione Puglia, 2022[88]) (Ministero delle infrastrutture e dei trasporti (MIT), 2021[71]). Overall, the PNRR will provide EUR 143 million to the project, of which 96.6 million allocated to the Municipality of Bari and the remaining amount allocated to Rete Ferroviaria Italiana, which will be the key actor in charge of project implementation (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]) (Comune di Bari, 2021[81]). The works should be concluded by March 2026 (BibLusBIM, 2021[69]). In the meantime, Studio Fuksas has already concluded the requalification of Parco Rossani (inaugurated in March 2022) and it is finalising the redevelopment of the former Caserma Rossani buildings, which will host a library and the Academy of Fine Arts of Bari (Redazione ANSA, 2022[89]) (RFI, 2022[85]).

4.10.3. Environmental considerations in project design, selection and funding

As mentioned above, the Nodo Verde project falls under Italy's PINQuA Programme[49] (BibLusBIM, 2021[69]; Ministero delle infrastrutture e dei trasporti (MIT), 2021[71]; Ministero delle infrastrutture e dei trasporti (MIT), 2021[90]), which, since 2021, was allocated a financial contribution of PNRR funds to enhance urban regeneration across the peninsula.[50] This link between PINQuA and the PNRR contributed to set more stringent criteria for project design and selection, as the allocation of PNRR funds is subject to projects' compliance with several sustainability and other criteria.

Sustainability criteria in project design (PFTE)

As for all projects funded by the PNRR, a Technical and Economic Feasibility Project (PFTE) assessment has been undertaken. In compliance with the new Ministry of Infrastructure and Transport's guidelines for the PFTE (see this report's Section on "*The new guidelines for PFTE: the introduction of the Sustainability Report"*), a Sustainability Report has been included in the PFTE of the Nodo Verde project. This includes a series of sustainability assessments, including (i) a "Do Not significant Harm" (DNSH) assessment, (ii) an assessment of the project plan's compliance with national Minimum Environmental Criteria (MEC) (*Criteri Ambientali Minimi*), and (iii) a preliminary rating by environmental and sustainability protocols like LEED and ENVISION V3 (RFI - Direzione Stazioni, 2022[83]).

In the context of the PNRR, the EU principle of "Do Not significant Harm" (**DNSH**) (see chapter 2) was explicitly taken into account in project design, as well as in the project selection phase (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]; Ministero delle infrastrutture e dei trasporti (MIT), 2021[71]). The eligibility of projects depended on their compliance with the DNSH in relation to six environmental objectives (i) climate change mitigation, (ii) climate change adaptation, (iii) the sustainable use and protection of water and marine resources, (iv) the transition towards a circular economy, (v) pollution prevention and control, and (vi) the protection and restoration of biodiversity and ecosystems (European Commission, 2021[91]). To verify the project's compliance with the DNSH principle, a preliminary Special Environmental Assessment was undertaken (RFI, 2022[92]). The assessment shows that the Nodo Verde project will not have a "significant and substantive impact" on any of the six objectives, and that the project will actively contribute to the achievement of the "climate change adaptation" and the "transition towards a circular economy" objectives (RFI, 2022[92]). Moreover, as part of the DNSH analysis, a **climate risk and vulnerability assessment** was also performed[51] to inform the uptake of relevant climate adaptation measures (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]). The evaluation focused on how the project will deal with the climate risks projected to affect the region going forward, which include increases in temperatures, strong winds, and violent storms (RFI, 2022[93]). Building on this assessment, and with a view to building resilience to these risks, the project plan includes various adaptation strategies and solutions, which include NbS elements. For example, indigenous vegetation species will be used, as these have a low irrigation requirement and are more resilient to high temperatures. Similarly, the green roof will contribute to reduce the heat-island effect in the surrounding area, reducing the amount of short-wave radiations reaching the ground surface and cooling the environment through plant transpiration (RFI, 2022[93]).

Besides, as part of the PFTE, an assessment of the project plan's compliance with minimum environmental criteria (MECs) (see this report's Section on *Green Public Procurement in Italy*) was also undertaken to the Nodo Verde project (RFI - Direzione Stazioni, 2022[83]). For each of these criteria, the assessment report highlights the existing requirements, their applicability to the Nodo Verde project, and the project's conformity with them (RFI, 2022[94]). In particular, three criteria (i.e. "natural and landscape inclusion", "landscaping of green areas", "reducing soil consumption and maintaining the permeability of soils") focus on the green elements that will be included in the project (RFI, 2022[94]).

Finally, the project plan and its sustainability were evaluated using the LEED (Leadership in Energy and Environmental Design) protocol and the ENVISION protocol (RFI - Direzione Stazioni, 2022[83]). The **LEED** protocol was used to rate the Nodo Verde project by assessing the sustainability of the buildings included in the project in terms of energy and resource consumption, users' comfort levels, indoor environmental quality, and others (RFI, 2022[85]). The assessment also accounts and values the inclusion of green components in the project, on the basis of various criteria, e.g. focusing on "*preserv[ing] existing natural areas and restor[ing] impaired ones to provide habitats and promote biodiversity"* and on "*minimising the effects on the microclimate and human and natural habitats through the reduction of the heat island effect"* (RFI, 2022[95]). In parallel, Nodo Verde's overall sustainability has been assessed through the ENVISION 3 protocol – i.e. a rating system that evaluates infrastructure projects' sustainability, taking into account both project characteristics and the long-term impacts on the surrounding communities (RFI, 2022[85]) (Institute for Sustainable Infrastructure, 2015[96]). Among the criteria set out by the ENVISION protocol, those applicable and achievable by Nodo Verde include "Enhance Functional Habitats", "Evaluate Risks and Resilience", "Preserve Undeveloped Land, and "Reduce Pesticide and Fertilizer Impacts" (RFI, 2022[97]). Further assessments will be undertaken as the project advances, to assess whether and how the sustainability measures included in the project plan will be implemented in practice (RFI, 2022[95]).

Sustainability criteria in project selection

The evaluation of the urban regeneration projects selected to receive PNRR funding under PINQuA relied on seven criteria, which included (i) environmental impact, (ii) social impact, (iii) cultural impact, (iv) urban

and territorial impact, economic and financial impact, both in terms of (v) activation of financial resources and (vi) involvement of private actors, and (vii) technological and procedural impact (Table 4.6) (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]).

Table 4.6. Criteria used in the project selection process

Criteria	Attributed weight
Environmental impact	15
Social impact	25
Cultural impact: Recovery and enhancement of cultural, environmental and landscape assets	10
Urban and territorial impact: No net soil consumption	15
Economic and financial impact: Activation of public and private financial resources	15
Economic and financial impact: Involvement of private actors	10
Technological and procedural impact	10
TOTAL	**100**

Source: (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]; Ministero delle infrastrutture e dei trasporti (MIT), 2022[98])

Compliance with project selection criteria was measured using 33 indicators. The five environmental impact indicators considered in project evaluation included energy sustainability (i.e. the use of renewable energy sources such as solar, aeolian, hydropower, geothermal, biomass) and energy efficiency (i.e. any improvements in the energy class of buildings), as well as considerations on resource use (i.e. share of reused or recycled materials) and origin (i.e. share of locally sourced resources), and environmental remediation (Ministero delle infrastrutture e dei trasporti, 2021[99]) (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]). A number of environmental sustainability considerations were also accounted for through the urban and territorial impact indicators, which assessed the share of uncovered and green urban areas as well as the development of pedestrian and cyclable paths and the connectivity of the project to public transports (Ministero delle infrastrutture e dei trasporti, 2021[99]). These indicators test one of the basic tenets of the PINQuA programme, i.e. avoiding the consumption and/or sealing of new soil (Ministero delle infrastrutture e dei trasporti (MIT), 2022[98]) (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]), (Ministero delle infrastrutture e dei trasporti, 2021[99]).

Based on these criteria and indicators, the project proposals presented by regional and local authorities – in the case of the Nodo Verde, by the Municipality of Bari – were assessed by a dedicated cross-ministerial High Commission. The Commission included twelve members from MIT, MiC, the Ministry of Interior, as well as the Italian National Association of Municipalities (i.e. *Associazione Nazionale Comuni Italiani,* ANCI), the Conference of the Regions and Autonomous Provinces (*Conferenza delle Regioni e delle Provincie Autonome*), and the Presidency of the Council of Ministers (most notably from the Department for Political Economy Planning and Co-ordination and from the Department for Digitalisation (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]). The Ministry of Environment was not involved in this Commission.

Other sustainability considerations in compliance with the existing regulatory framework

The Nodo Verde project was also subject to several other environmental considerations through national, regional, and local regulatory plans. On this basis, in a few instances additional measures had to be undertaken to ensure the project plan's alignment with the existing regulatory framework. For example, as the Municipality of Bari falls within a zone subject to high transport and industrial pollution, the Nodo Verde project envisages the installation of dust sheets or nets as well as other measures to reduce air pollution during the construction phase, in line with the Regional Air Quality Plan (RFI, 2022[85]). Similarly, the proximity of the project to areas subject to high-flood risk made it mandatory to highlight in the project plan

the water discharge points that can help avoid flood risk in the event of extreme precipitation, in line with the Flood Risk Management Plan. In addition, the semi-natural terrain of the artificial hill will contribute to contain flood risk by draining and collecting water through a system of channels and tanks (RFI, 2022[85]) (RFI - Direzione Stazioni, 2022[83]). The excess water collected in these tanks can then be reused for irrigation and firefighting purposes (RFI - Direzione Stazioni, 2022[83]). By increasing connectivity across neighbourhoods and developing pedestrian and cycling mobility options, the project is also aligned with **local environmental objectives and requirements** (RFI - Direzione Stazioni, 2022[83])., including the goals set out in the Metropolitan City's Urban Sustainable Mobility Urban Plan (*Piano Urbano Mobilità Sostenibile*, PUMS).

4.10.4. Conclusions

The Nodo Verde project represents a good example of how urban GI and NbS can contribute to several environmental, social and economic objectives simultaneously, creating value and multiple benefits for the surrounding community. At the same time, the project also shows how – when adequately planned, urban regeneration projects can contribute to enhance the sustainability and resilience of urban areas to the risks and impacts posed by climate change, as well as to broader environmental risks and degradation.

In the Italian context, the PINQuA programme provides a valuable and promising framework to promote urban GI and NbS throughout the national territory, as several sustainability criteria are considered in the project selection phase. Among PINQuA's eligibility criteria, the particular attention to avoiding development of new land is particularly important, as Italy already displays one of the highest percentages of sealed surface in the EU (Di Pirro et al., 2022[63]). The sustainability requirements introduced by the PNRR – and most notably the DNSH and climate risk and vulnerability assessments – also play an important role, tying funding allocation to specific sustainability requirements, and thus contributing to mainstreaming climate change and environmental sustainability in project design and planning. Indeed, according to the stakeholders involved, while on the one hand the sustainability criteria set out by PINQuA and the PNRR served as a basis for better project selection, on the other they also provided a stimulus towards better project design (Ministero delle infrastrutture e dei trasporti (MIT), 2022[82]). In addition, the Sustainability Report required as part of the Technical and Economic Feasibility Project (PFTE) assessment also plays a key role in mainstreaming GI and NbS in urban regeneration processes. Yet, the absence of the Ministry of Environment – as well as of other stakeholders specialised in environmental and climate issues, such as for example ISPRA – in the cross-ministerial High Commission responsible for selecting the PINQuA projects represents a missed opportunity in Italy's effort to green the infrastructure sector.

Some recommendations for improving the integration of GI and NbS into urban planning and project implementation are:

- The criteria set out by PINQuA and the PNRR should be expanded and mainstreamed in broader urban regeneration processes, for example by being integrated in the regional and local regulatory framework, establishing a new standard for urban regeneration projects throughout the national territory. At the same time, resources for urban regeneration projects should be made available for smaller towns and villages as well. Indeed, while these settlements are often those suffering the most from the lack of awareness and resources for GI and NbS financing programmes such as PINQuA and PNRR usually tend to exclude these smaller realities, only contributing to widen the gap between urban and rural areas.
- GI and NbS should be integrated in a strategic manner in the territory, with a long-term vision for the municipality, the metropolitan area, and the surrounding territory. This includes the planning and implementation of green elements in line with the specific needs and characteristics of each territory, based on existing environmental challenges and climate risks, as well as on existing opportunities and assets. The experience of the City of Torino, which in 2021 approved its Strategic

Plan for Green Infrastructure (Piano Strategico dell'Infrastruttura Verde) (Comune di Torino, 2021[100]) as a planning and analytical tool to plan better policies and investments for green infrastructure, represents a best practice that could be replicated in other cities throughout the Country to enhance the framing of GI and NbS as strategic assets. Several elements need to be considered in urban and peri-urban GI planning, including:

  - the net contribution of the planned green infrastructure to the environmental sustainability and climate resilience of the project site and surrounding area, as well as to other socio-economic considerations (e.g. the social context, existing inequalities, etc.);
  - the resilience of the planned infrastructure to future environmental and climate challenges, based on scaled-down climate and environmental scenarios;
  - the connectivity with other green areas and biodiversity hotspots;
  - the multiple ecosystem services, co-benefits, and economic returns likely to result from GI implementation;
  - the need to avoid maladaptation, for example by avoiding using invasive or non-native species that can disrupt local ecosystems or enhance climate risks (e.g. planting flammable vegetation in fire-prone areas).

- More collaboration is needed between the Ministry of Infrastructure and Transport and the Ministry of Environment. Most notably, environmental and climate experts from the Ministry of Environment, as well as from other specialised governmental and non-governmental agencies, should be closely involved throughout the project's lifecycle, and most notably during the appraisal and selection stage. This element is particularly critical in light of the need to avoid maladaptation.
- Enhancing collaboration among public and private actors – including through public-private partnerships (PPPs) is also critical, with a view to scaling up available finance for green infrastructure. The City of Milano's ForestaMI experience represents a successful example of how engaging private companies can result in successful outcomes (Comune di Milano, n.d.[101]). At the same time, as in most Italian metropolitan cities available surfaces to host GI are missing, co-operation with the private sector can offer new opportunities to make space for nature, e.g. by greening existing grey infrastructure (e.g. through green roofs) or de-sealing currently sealed surfaces.

4.11. The role of dams in Italy: An overview

Dams represent a key infrastructure in Italy. After World War II, the country underwent a period of steep economic growth, which has been accompanied by an intense expansion of infrastructure systems, including the construction of dams to secure Italy's energy and water supply. Dam development in Italy reached its peak around the 1970s and 1980s (ITCOLD, 2021[102]). Today, the country's territory hosts more than nine thousand dams[52], of which 533 are classified as *grandi dighe* (i.e. large dams) (CISL FP, 2008[103]). The term "large dams" is conventionally used to refer to all river dams exceeding 15 metres in height or with a reservoir volume exceeding one million cubic metres (Council of Ministers, 1994[104]). Among Italy's large dams, approximately 73% are in operation, 15% are in their testing phase, while approximately 5% are out of operation for technical reasons and 2% are under construction (CISL FP, 2008[103]) (Facchini, 2018[105]). From an institutional perspective, large dams fall under the competence of the national government,[53] while all other dams fall under the competence of the regions (as per Legislative Decree 112/98) (CISL FP, 2008[103]).[54] Overall, Italian dams serve several important functions and are recognised as a strategic economic asset at the national level. While 61% of currently existing large dams store water for hydroelectric purposes, 26% are used for irrigation purposes, 12% for potable water supply, and less than 2% for industrial purposes (Rosso, 2017[106]). In most cases, dams also contribute to

mitigating the risk of flooding in the occurrence of extreme precipitation (CISL FP, 2008[103]) (Facchini, 2018[105]).

While dams deliver important services, they also bring about some key challenges in relation to their environmental impacts, their management requirements, and their overall resilience to climate and environmental changes. Dams can have negative impacts on biodiversity, biophysical processes, and ecosystem services (Encyclopedia of the Environment, 2019[107]). Most of these impacts usually occur downstream, though some impacts also affect the upstream stretch of rivers, as well as the very area where the dam is located. One of the key environmental impacts of dams is the alteration of the balance between the inflow and outflow of sediments (CISL FP, 2008[103]) (Encyclopedia of the Environment, 2019[107]). Indeed, as they physically alter the natural flow of watercourses and create an artificial basin characterised by low currents, dams capture sediment, leading to the creation of an area with high sediment concentrations (Encyclopedia of the Environment, 2019[107]) (CISL FP, 2008[103]). Overall, approximately 70-90% of the sediments of rivers feeding into dams is normally retained by these infrastructures (Encyclopedia of the Environment, 2019[107]). This can lead to severe ecological problems downstream (CISL FP, 2008[103]) (Encyclopedia of the Environment, 2019[107]), with impacts on biodiversity and ecosystems (e.g. impacts on both flora and fauna) (Encyclopedia of the Environment, 2019[107]) (CISL FP, 2008[103]). In addition, by capturing large shares of sediment, dams also limit the transportation of valuable nutrients downstream, thus affecting the fertility of watercourses, as well as soil quality (Encyclopedia of the Environment, 2019[107]). Besides, the accumulation of sediments in reservoirs also affects the biophysical dynamics of the riverbed downstream, favouring both riverine and coastal erosion (CISL FP, 2008[103]). The alteration of water and sediment flows can also affect the turbidity of watercourses – on which certain species rely to hide from their predators (Encyclopedia of the Environment, 2019[107]). Furthermore, dams affect the distribution of water in watercourses significantly reducing the amounts of water available downstream, with impacts on ecosystems as well as on the communities that rely on them. Dams also constitute a barrier for fish species that need to travel upstream for reproduction, which can have significant impacts on the size of their population, with consequences on the whole ecosystem balance. Finally, through the alteration of geological processes, in some cases dams can also cause geological instability. Overall, while significant, the environmental impacts of dams on watercourses largely depend upon a number of factors, e.g. the dam's height and width, its location, the underlying ecological dynamics of the river and the surrounding environment, the implementation of mitigating measures, etc. (Encyclopedia of the Environment, 2019[107]).

In addition to environmental considerations, the maintenance of dams is another particularly crucial challenge (CISL FP, 2008[103]). Dams demand constant oversight and the implementation of specific maintenance interventions to operate safely and avoid dam failure (CISL FP, 2008[103]). These interventions usually require significant and continuous resources as well as specific technical competences. Dam oversight and maintenance in Italy is particularly critical as the average age of these infrastructure in Italy exceeds 60 years (ITCOLD, 2018[108]). Today, dam maintenance is included in Italy's strategy to optimise environmental resources, as per Legislative Decrees 152/99 and 152/2006.

Climate change has had an increasingly important impact on the operation and sustainability of dams in Italy. Floods and droughts, which are both fuelled by climate change, can severely disrupt dam operations, and cause cascading damages and harm to the environment and communities downstream of their operations. Integrating resilience in dam design and maintenance is thus crucial to avoid negative impacts of climate-related extreme weather events. When dams are resilient themselves, they can also enhance resilience of their surrounding areas. For example, by storing and regulating water flows, dams can help reduce flood and drought risk, as proven for example during the intense drought that hit Italy in summer 2022 and that brought various regions to declare the state of emergency. Yet, today, 60% of the artificial basins created by Italy's large dams have a surface area of less than 100 km^2 (CISL FP, 2008[103]). This, combined with the particular orography of the Italian territory, exposes the existing reservoirs – both large dams and regular ones –, to highly variable water loads (CISL FP, 2008[103]). For example, in the Emilia

Romagna region, climate-related extreme events are projected to increase soil erosion, with significant impacts on dams' volume capacity for freshwater storage (with cascading impacts on drinking water supply, agriculture, and other sectors), as well as for hydroelectricity production (Regione Emilia Romagna, 2019[109]) (ARPAE Emila Romagna, 2013[110]).

Overall, in the past decades, the socio-economic and environmental costs entailed by dam construction have become a growing concern among the Italian population, which has started demanding for *ex ante* assessments that would take into account the costs (including environmental ones) and benefits of the construction of these infrastructures (ITCOLD, 2021[102]). Public demand for such types of assessments equally applies to the construction of new "large dams", as well as to the management of the existing ones (ITCOLD, 2021[102]).

4.12. Ensuring the long-term sustainability of dams through green measures: The case of Ridracoli dam

4.12.1. Project context and objectives

Built between 1974 and 1982, the Ridracoli dam is an artificial dam of the Bidente River and of the Celluzze stream in the Emilia Romagna region. The artificial basin of Ridracoli is located in the municipality of Bagno di Romagna, in the Romagna Apennines (in the province of Forlì-Cesena) at an altitude of 557 metres above sea level (Ridracoli, n.d.[111]). Overall, the lake covers almost 5 kilometres, partially falling under the territory of the Casentinesi Forests, Monte Falterona and Campigna National Park – which is part of the Natura 2000 network. (IDRO, n.d.[112]) (Ridracoli, n.d.[111]) (ARPAE Emilia Romagna, 2016[113]). With over 103 metres in height and 432 metres in width at its crest, Ridracoli is labelled as a "large dam" under Italian legislation (IDRO, n.d.[112]) (Romagna Acque - Società delle Fonti, 2007[114]).

The dam reservoir serves several objectives at once. It (i) supplies freshwater in the region, thus easing the pressure on groundwater resources; (ii) produces hydroelectric energy; (iii) regulates the flow of the Bidente River, significantly reducing flood risk; and (iv) contains land subsidence processes by reducing groundwater extraction.[55] The artificial basin and the requalification of the surrounding area have also provided other indirect socio-economic benefits, creating employment, business, leisure, and environmental education opportunities (Romagna Acque - Società delle Fonti, 2007[114]) (ITCOLD, 2021[102]). The construction of the dam, along with some dedicated financial resources made available by Romagna Acque, have significantly contributed to contrast the marginalization and depopulation of the area (Romagna Acque - Società delle Fonti, 2007[114]) (ITCOLD, 2021[102]) (ARPAE Emilia Romagna, 2016[115]).

The freshwater supply role of the Ridracoli dam is particularly noteworthy. The artificial reservoir can hold up to 33 billion litres of water (IDRO, n.d.[112]) (Ridracoli, n.d.[111]), which feed into the Romagna Aqueduct (Figure 4.8), an infrastructure that supplies water to several provinces in the Emilia Romagna region (DG Dighe, n.d.[116]). Overall, Ridracoli is estimated to supply water to nearly one million residents (as well as to an estimated 50 million tourists every year) across over 50 municipalities in the Romagna Riviera and the neighbouring plains, including to major cities such as Rimini, Riccione, Cattolica, Milano Marittima and Cesenatico, among others (Ridracoli, n.d.[111]) (ITCOLD, 2021[102]) (ARPAE Emilia Romagna, 2017[117]). With approximately 50% of the Romagna area depending on Ridracoli for freshwater supply, the dam represents thus a strategic asset in the region (Conti, 2022[118]) (ARPAE Emilia Romagna, 2016[115]). This role is particularly critical during periods of drought, as proven for example during the 2022 summer, when the dam has ensured effective water supply in spite of the severe drought conditions affecting the region (Luongo, 2022[119]) (Redazione, 2017[120]) (ARPAE Emilia Romagna, 2017[117]).

Figure 4.8. The Ridracoli dam and the Romagna area aqueduct

Source: (Romagna Acque - Società delle Fonti, 2007[114])

4.12.2. Institutional and regulatory framework

From an institutional perspective, the key actors involved in the management of the Ridracoli dam include the regional and provincial government, Basin Authorities (*Autorità di Bacino*), as well as the Regional Environmental Protection Agency (ARPAE). Municipalities and Mountain Communities (*Comunità Montane*), as well as business and the civil society organisations (e.g. WWF, Confindustria, etc.), also regularly take part in specific planning or consultation processes (Regione Emilia Romagna, 2021[121]). The Ridracoli dam is operated by Romagna Acque Società delle Fonti S.p.A (henceforth Romagna Acque).

From a regulatory perspective, the key tools for water management are the River Basin Management Plan and the Water Protection Plan. The River Basin Management Plan (*Piano di Gestione delle Acque*, PGA), adopted by the Northern Apennines River Basin District (which includes the Ridracoli network), is a strategic and operational tool to guide water bodies' protection and the planning and monitoring of relevant measures (ARPAE Emilia Romagna, 2016[113]). Emilia Romagna's PGA foresees several measures, including GI, to protect, enhance and restore ecosystem quality and connectivity (Autorità di bacino distrettuale, 2021[122]). The regional Water Protection Plan (*Piano di Tutela delle Acque*, PTA) aims to ensure water quality for internal and coastal waters and the long-term sustainability of water supply (Regione Emilia Romagna, 2021[121]) (ARPAE Emilia Romagna, 2021[123]) (Regione Emilia Romagna, 2006[124]) (DG Ambiente Regione Emilia Romagna, n.d.[125]). Emilia Romagna's PTA encourages the uptake of GI such as for example river renaturation, environmental remediation, as well as a guaranteed minimum water flow (Regione Emilia Romagna, n.d.[126]). The PTA is also closely linked to the strategic

environmental evaluation (*Vautazione ambientale strategica*, VAS), which helps to assess the environmental impact of all PTA measures (Regione Emilia Romagna, 2005[127]). Both the River Basin Management Plan and the Water Protection Plan comply with European Directive 2000/60/EC and the national legislative decree 152/2006.

4.12.3. Environmental considerations throughout the project's lifecycle

The Ridracoli dam has been planned in the 1960s, its development precedes many of the environmental regulations and requirements in place today (Romagna Acque - Società delle Fonti, 2007[114]). Yet, environmental considerations have been considered throughout the whole project lifecycle.

Sustainability considerations in project planning, selection, and monitoring

During the design and planning phase, an *ex ante* assessment of the overall environmental impacts of the infrastructure has been performed. This assessment has been subsequently incorporated into the design process (ITCOLD, 2021[102]). The assessment also included an evaluation of the costs and benefits resulting from the development of the infrastructure (ITCOLD, 2021[102]).

During the project selection phase, the selection of a suitable location to host the dam took into account various environmental considerations, in addition to other technical criteria (e.g. water and soil characteristics). Selection criteria included the presence of coppice forests near the reservoir (which would reduce erosion), a contained disruption of the Bidente River flow, as well as the absence of industrial settlements leading to pollution risk in the derivable basins (ITCOLD, 2021[102]) (Romagna Acque - Società delle Fonti, 2007[114]). The location of Ridracoli was selected over to two other locations, as it was estimated to facilitate the fulfilment of the dam's goals (ITCOLD, 2021[102]). Ridracoli was also considered a less environmentally harmful option as compared to the other solutions considered, which included groundwater extraction and the diversion of the Po River (ITCOLD, 2021[102]).

The monitoring and management of environmental risks and impacts (Box 4.14) are key elements of the management of Ridracoli. Romagna Acque and the ARPAE oversee the monitoring of water and environmental quality, in compliance with EU and national legislation (ARPAE Emilia Romagna, 2016[113]) (ARPAE Emilia Romagna, 2021[123]), which put particular emphasis on water quality monitoring, as well as on the environmental condition of water bodies, on the basis of ecological and chemical assessments.[56] The impact of the dam on the river flow is also monitored and carefully managed. Overall, the operations of the Ridracoli dam have a contained impact on the Bidente-Ronco River flow, whose outflow at the river mouth is estimated to be reduced by 15% (Romagna Acque - Società delle Fonti, 2007[114]).

Box 4.14. Monitoring and managing water scarcity at Ridracoli

In the Emilia Romagna region, the ARPAE assesses water scarcity risk, using precipitation forecasts that are converted in volume inflow and allow to estimate the potential for the recharge of the Ridracoli dam for the following year (Chahoud et al., n.d.[128]). In addition, some structural measures to reduce drought risk were also implemented. Most notably, the dam has been linked to an integrated water supply system, which integrated surface and groundwater sources as well as several regional facilities – including reservoirs, tanks, and water purifiers – to minimise water extraction from the Ridracoli basin during drought periods (ARPAE Emilia Romagna, 2017[117]) (Romagna Acque - Società delle Fonti, 2007[114]). Despite the severe droughts experienced in recent years, this system has so far ensured a water level at Ridracoli sufficient to ensure water supply over the whole territory (Romagna Acque - Società delle Fonti, 2007[114]).

Source: (ARPAE Emilia Romagna, 2017[117]; Romagna Acque - Società delle Fonti, 2007[114]; Chahoud et al., n.d.[128])

The use of GI for environmental remediation

To reduce the environmental impacts observed in the area surrounding the dam, and most notably a major problem of soil erosion that was leading to the silting of the reservoir, as well as to reduced water quality (Regione Emilia-Romagna (DG cura del territorio e dell'ambiente), n.d.[129]), a variety of ecosystem conservation, enhancement and restoration interventions have been realised in the area of the Ridracoli hydrographic basin. Since the 1980s, these interventions have included (i) the reforestation and renaturation of the hill slopes surrounding the dam that had been sealed or damaged, through the replanting of coppice woods, which have contributed to contain soil erosion and restore natural ecosystems on a largely renaturation; and (ii) naturalistic engineering interventions, including hydrogeological interventions (e.g. through hydraulic regulation) and consolidation of the slopes; and (iii) the recovery of ancient forest paths and trails, for the benefit of both tourists and visitors as well as Romagna Acque operators (e.g. for the placement of technical equipment for the control of landslides and rainfall measurements); and (iv) research programmes on environmental protection targeted to the basin area. Altogether, between 1981 and 1995, a total of EUR 4.6 million was mobilised for these interventions. (Romagna Acque - Società delle Fonti, 2007[114]) (ARPAE Emilia Romagna, 2016[115]).

These environmental remediation measures are undertaken by relevant stakeholders (e.g. Romagna Acque, the Ministry of Agricultural and Forestry Policies, the Province of Forlì-Cesena, the Consortium of Reclamation of Central Romagna, etc.) (Romagna Acque - Società delle Fonti, 2007[114]). Romagna Acque is usually closely involved in these interventions, either by undertaking them directly of by financing and supporting them indirectly. Between 1996 to 2008, Romagna Acque set up a special fund to finance the environmental remediation of the areas surrounding the dam. Over little more than a decade, the fund raised a total of EUR 8 million generated through a 3% levy on the water sale revenues (ARPAE Emilia Romagna, 2016[130]).

Since 2008, the levy has been substituted by a regional tariff system, which has been used to set up a scheme of payment-for-ecosystem-services (Regione Emilia-Romagna (DG cura del territorio e dell'ambiente), n.d.[129]) in the area. Using the revenues from the dam's water tariff, the system remunerates local forest owners that engage in sustainable forest management practices, encouraging more sustainable forest management and compensating local forest owners for the costs incurred in the process (Regione Emilia-Romagna (DG cura del territorio e dell'ambiente), n.d.[129]). The payment amounts to EUR 100/ha, i.e. 3% of the total revenue obtained from the water tariff (Romagna Acque - Società delle Fonti, 2007[114]) (Regione Emilia-Romagna (DG cura del territorio e dell'ambiente), n.d.[129]). As a result of improved forest management, soil erosion has significantly decreased, while water quality and ecosystem services have substantially improved.

4.12.4. Conclusions

The introduction of a series of environmental remediation mechanisms and the setup of the ecosystem payment scheme in the area surrounding the dam has been considered a best practice in dam management in Italy (ITCOLD, 2021[102]), as it has enhanced the reforestation of the hillslope surrounding the dam, thus improving ecosystem services and forest management, while at the same time redistributing the benefits from the assets to the local community (ITCOLD, 2021[102]). The involvement of the local community – most notably local forest owners – has also been considered a good example that could be implemented elsewhere (ITCOLD, 2021[102]). Overall, the interventions implemented at Ridracoli make the asset align with the guidance provided by the World Commission on Dam in its 2000 report (World Commission on Dams, 2000[131]).[57]

The Ridracoli dam also offers a good example of the advantages of integrating ecosystem services in economic accounting. Indeed, while on the one hand doing so benefits environmental protection, at the same time enhanced environmental quality represents an economic investment that benefits asset

operators and managers, as well as the broader territory. Such investment can be measured, for instance, in terms of water quality gains and energy savings (ITCOLD, 2021[102]).

The Ridracoli dam also highlights the importance of considering climate risks and environmental challenges to infrastructure assets as early as possible in an asset's lifecycle – to minimise risks and impacts. This means for example undertaking climate and environmental risk assessments at different stages of the asset life (i.e. from project design to dismissal), building on scaled-down climate and environmental scenarios that adequately represent existing and projected hazard at the local level. In the case of dams, it is particularly critical to consider the challenges posed by changing precipitation patterns. Indeed, on the one hand, the increase in the frequency and intensity of extreme precipitation events pose the challenge of managing excess amounts of water (for which existing dams might not be ready) and increases the risk of hillslope erosion and of landslides, in the most extreme cases challenging the stability of the infrastructure. On the other hand, the decrease in the overall volumes of precipitation throughout the year can pose significant challenges to the ability of existing and planned dams to successfully deliver their services. While the efforts undertaken to enhance the resilience of the Ridracoli dam to water scarcity have proven rather successful in recent years, continued (and if necessary increased) efforts are needed, given the dam's strategic importance for water supply in the region.

It is also critical to ensure that dam infrastructure minimises ecosystem disruption. This means undertaking environmental impact assessments with a focus on all the ecosystems potentially affected by the asset – which, in many cases, might go far beyond the site where the dam is located. Environmental impact assessments should primarily focus on the ecological conditions of the water course(s) affected by the dam (Regione Emilia Romagna, 2019[109]), focusing on the artificial basin as well as on downstream and upstream impacts. Environmental impact assessments should be carried out at different stages of the asset life (i.e. from project design to dismissal) and be accompanied by measures to ensure the remediation or containment of any unavoidable impacts, with a particular focus on (i) ensuring an adequate water flow throughout the year and (ii) anticipating and minimising potential conflicts for water resource allocation (Regione Emilia Romagna, 2019[109]). As the size of the asset is not necessarily proportional to its potential impacts, it is crucial to undertake environmental impact assessments for dams of all sizes – without neglecting smaller dams, whose operation is often supported by a lower amount of information (CISL FP, 2008[103]).

Green infrastructures offer valuable tools to address, at least partially the harmful environmental impacts of dams. For example, the re-greening of the Ridracoli dam hillslope represents a good example of how GI can play a role in compensating the environmental impacts of grey infrastructure and in enhancing their resilience to climate change, while at the same time creating multiple other benefits for the surrounding ecosystems, communities, and economies. At Ridracoli, the forest environment is integrated with the ecosystems created by the presence of the dam, creating a complex dam-forest environment.

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Notes

[1] The fact-finding Mission took place on 20 and 21 July 2022, in Rome.

[2] For example, the 1991 Frame Act on protected areas, which provides a detailed regulation on the definition and management of protected areas in Italy; the 1997 Decree for the Protection of Habitats, Flora and Fauna, which transposes the EU Habitats Directive in the national law; and the 2007 Ministry Decree on minimum uniform criteria for the definition of conservation measures specific to Natura 2000 sites.

[3] Non-urban green areas (beyond agricultural areas) are regulated by specific instruments and agricultural areas with an important naturalistic value (e.g. EUAP, SAC, SPA, etc.) are also subject to specific regulatory restrictions. In addition to that, Local Urban Plans are defined starting from the natural characteristics of the municipal territory, which are assessed and identified through the instrument of the "Use of Soil" Charter.

[4] Italy aligns with the EU Green Deal and the initiatives coming from it (i.e. the EU Climate Law and Plan, the 2030 Climate Targets, the Fit for 55 package, etc.), it is signature of all major international agreements and conventions on climate and the environment (i.e. Paris Agreement, the UNFCCC, etc.), and, at the national level, it has launched a series of initiatives to strengthen its commitment to sustainable development, such as the creation of a Ministry of Environment and Energy Security (MASE) in 2021 or the allocation of a large part of PNRR funds to green interventions.

[5] Within MIT, there are different public agencies that deal with NbS/GI specific to transport infrastructure, such as Italian Railway (RFI/FS), the National Highway Authority (ANAS), the National Agency for Flight Assistance (ENAV), National Civil Aviation Authority (ENAC), Port System Authority (AdSP).

[6] On 21st January 2021, MIT presented the new framework during an online seminar "Opere Pubbliche: programmazione, scelte di policy e criteri di valutazione. Verso la definizione di un modello per lo sviluppo sostenibile" (Ministero delle infrastrutture e dei trasporti (MIT), 21 January 2022[36]).

[7] An environmental tax is a tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment (Eurostat, 2013[135]). It can be defined as a tax levied on activities which are considered to be harmful to the environment and is intended to promote environmentally friendly activities via economic incentives. A notable example is the carbon tax.

[8] Also, the autonomous provinces of Trento and Bolzano have their own agency for environmental protection – known as APPAs

[9] For urban planning specifically, the constitutional case law has established that State and regional law can set some limits to certain municipal powers, while always having regard to the general interest for the protection of the territory, and conditionally on neither cancelling out nor compressing municipalities' powers radically (Formez PA, 2020[132])

[10] MoC collaborates with the regions for the development of the Regional Landscape Plans.

[11]The RER consists of Core Areas or Nodes, Ecological Connections, Project Areas (Buffer Areas, Nodes Areas, River Areas, and Environmental Passages) and Environmental Reclamation Areas.

[12] With the Law 56/2014, Italian provinces are no longer considered as administrative authorities within Italian regulatory and legislative system. The Law also transformed ten of the previously existing provinces into Metropolitan Cities (Bari, Bologna, Genoa, Florence, Milan, Naples, Rome, Turin, Venice and Reggio Calabria – four additional metropolitan cities have been identified by the special statute regions, i.e. Cagliari, Catania, Messina, Palermo. For this reason, to date, the PTP and the PTCP are managed mainly by the relevant regional authorities, with some tasks and responsibilities given to the corresponding Metropolitan Cities.

[13] In Lombardy, the LUP has been substituted Land Government Plan (LGP). The LGP consists of three separate acts: (1) Development Plan containing key information on the municipal territory and outlines the development trajectories the municipal administration intends to pursue. It also defines the geological, hydrogeological and seismic conditions of the municipal territory; (2) Plan on Services concerning the modalities to integrate facilities of public and general interest in cities; (3) Regulatory Plan containing the regulatory framework and quality evaluations for cities (Regione Lombardia, 2022[133]).

[14] Milan has also been selected to be part of the 100RC Project.

[15] The 14 Metropolitan Cities in Italy are Roma Capitale, Milano, Napoli, Torino, Bari, Palermo, Catania, Bologna, Firenze, Venezia, Genova, Messina, Reggio Calabria and Cagliari. Within the PNRR, the decision was to focus on these cities as they are increasingly exposed to environmental challenges, such as air pollution, climate change impacts and extreme weather events, and the loss of biodiversity. These have serious consequences for the well-being and health of their citizens (I.e. almost 21 million people).

[16] The 2021-2050 PTE was realised by the Inter-Ministerial Committee for the Ecological Transition (CIPE), coordinated by MASE. This first version of the Plan will be subject to periodic adjustments based on the technological evolution as well as the development of the economic and social policies supporting the Plan's measures.

[17] The Legislative Decree 152/2006 entered into force on 31 July 2007. It was subsequently amended and complemented by the Legislative Decree 4/2008 and Legislative Decree 29/2010.

[18] The consultation process engages the general public and local communities interested in the environmental impacts resulting from the implementation of the plan, as well as public administrations and agencies with environmental competencies and responsibilities.

[19] Biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape.

[20] A systemic process to continually improve management policies and practices by learning from the outcomes of previously employed policies and practices (European Commission, 2013[29]).

[21] According to the principle of preventive action, the best environmental policy is to prevent rather the negative effects of a project rather than trying to reduce or offset them once they have already taken place.

[22] In the EU, the EIA has been introduced in 1985 with the Directive 85/337/EEC. This Directive has been modified five times: in 1997, 2003, 2009, 2011, and 2014. The last version dates back to 2014 with the Directive 2014/52/EU.

[23] Since its entry into force on 29 April 2006, the Code has undergone numerous amendments and additions. Some of the main amendments include the legislative decree 16 June 2017, n. 104, for the transposition of the EU Directive on EIA 2014/52/EU); the Law Decree 34/2020 (converted by Law 77/2020) for the abolition of the VIA Technical Committee; the Las Decree 76/2020 (converted by Law 120/2020) for rationalization of EIA procedures; the Law Decree 77/2021 simplifications (converted with L. 108/2021) for the acceleration of the environmental and landscape process, new EIA regulations and special provisions for PNRR-PNIEC interventions ((Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA), n.d.[32]).

[24] The Technical Committee for the Verification of the Environmental Impact (both for the EIA and SEA) operates within MASE through the Plenary Assembly, the Subcommittees EIA/SEA, and the Technical Groups Instructors and, for procedures which have a shared regional interest, it is also complemented by designated experts for each of the regions and autonomous provinces that are territorially competent.

[25] Directorate General for Environmental Assessments (DGVA) within MASE.

[26] The Legislative Decree 32/2019 (also known as *Sblocca Cantieri*) and the Legislative Decree 72/2020 (also known as *Simplification Decree*) have accelerated and streamlined the procedures for the environmental assessments of projects.

[27] Legislative Decree 77/2021 converted into Law 108/2021: “acceleration of the environmental and landscape process, new EIA regulations and special provisions for PNRR-PNIEC interventions”.

[28] According to the rules set by the European Commission for the disbursement of the funds of the Next Generation EU plan, Member States have to stick to a series of objectives and timeline. Funds are indeed paid by instalments upon completion of targets and milestone by certain tight deadlines.

[29] The new evaluation framework was launched under the previous Minister Enrico Giovannini, who had changed the name of the ministry into the Ministry of Sustainable Infrastructure and Mobility (MIMS).

[30] The SNSvS defines the national reference framework for environmental and territorial planning, programming and assessment processes to implement the sustainable development goals of the 2030 Agenda. The most recent version of the Strategy has been approved by CIPE with Resolution No. 108 back in 2017, but it is supposed to be updated every three years. The National Reform Programme (NRP) and the Document on Economics and Finance (DEF) are key documents for the implementation of the Strategy. Moreover, the proposed actions and the operational instruments must also be compatible with the binding objectives at the Community level.

The National Sustainable Development Strategy 2017-2030 is the main tool for the creation of a new circular economic model, low CO_2 emissions, resilient to climate change and other global changes due to local crises, such as loss of biodiversity, modification of fundamental biogeochemical cycles (carbon, nitrogen, phosphorus) and changes in land use (Agenzia per la coesione territoriale, n.d.[134]).

[31] To date, operational guidelines have been issued just for public investments in railway (in December 2021), road transport (in July 2022), and fast public transportation (September 2022, currently undergoing public consultation), but the Ministry is committed to extend them to the other sectors, starting with mass transport.

[32] These new guidelines were issued by the Higher Council for Public Works specifically for infrastructure projects financed with PNRR funds, but they can be applied, more generally, to any large-scale infrastructure projects.

[33] The estimates must be validated by a third-party certifier according to internationally recognized protocols and standards.

[34] Climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition towards the circular economy, prevention and reduction of pollution, ecosystem and biodiversity protection and restoration (article 9 of the EU Regulation 2020/852).

[35] The PFTE outlines the (i) geometric-spatial structure of the project, (ii) the foundation, structural and functional types of the work (without explicit calculations), (iii) the work's interference with the sub-services and with the archaeological cultural heritage, (iv) mitigation and compensation measures to reduce the environmental impact and the impacts on the archaeological setting, (v) an expenditure forecast based on the award procedure.

[36] GPP refers to a set of practices aimed at introducing environmental considerations in the procurement process, while GI and NbS are mainly products, goods, and services to be procured.

[37] The new Code of Public Contracts (abrogating the 2006 Code) was issued with the Legislative Decree of 18 April 2016, n. 50, and transposed the EU 2014 Directives on Public Procurement. The 2016 Code has been further modified with the Legislative Decree of 19 April 2017, n. 56, which entered into force on 20 May 2017.

[38] The other countries are Norway, Czech Republic, and Cyprus*.

*Note by the Republic of Türkiye

The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[39] Decree of 10 April 2013

[40] Federparchi and Assosistema, the Department of economic and social sciences of the University of Padua, and firms like Eurosintex, Novamont, and Adlaw Administrative lawyers.

[41] According to the Ministerial Decree of 21 September 2016, the GPP Management Committee is composed by representatives of the three relevant Ministries (Ministry of Environment and Energy Security, Ministry of Economic Development, and Ministry of Economy and Finance), ISPRA, CONSIP, ENEA, some experts from ARPA, and two representatives of the Regions.

[42] See https://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/italy/2014it16m2op004

[43] Jaspers (2021) - Independent quality review "Asse Ferroviario Palermo-Catania-Messina. Raddoppio della tratta Bicocca-Catenanuova".

[44] Ibid

[45] Jaspers (2021). Independent quality review "Asse Ferroviario Palermo-Catania-Messina. Raddoppio della tratta Bicocca-Catenanuova"

[46] Ibid

[47] Under a 2°C and 4°C warming scenario respectively.

[48] In both examples, national averages are calculated over the totality of Italy's metropolitan cities and/or regional or province administrative centres. In the latter example, the figure refers to "urban parks of significant public interest".

[49] Nodo Verde was identified as one of the 8 pilot projects (i.e. "*progetti pilota ad alto rendimento*") under PINQuA.

[50] In particular, PINQuA is set to receive a total of EUR 2.8 billion, including EUR 477 million in national resources, as set out in Italy's 2021 Budget Law and in a number of other regulatory provisions (Ministero delle infrastrutture e dei trasporti (MIT), 2022[98]).

[51] This analysis was mandatory for all projects receiving over EUR 10 million in PNRR funding.

[52] In Italy, the term *diga* (i.e. dam) refers to a structure built at the bottom of a valley, in a section generally characterised by a small width (narrow or gorge) and extending transversally across its entire width, with the function of retaining all or part of the outflow of a watercourse, from which an artificial lake or reservoir thus originates (CISL FP, 2008[103]).

[53] In particular, the Ministry manages safety control of big dams and strategic water infrastructures including (i) the approval of projects; (ii) surveillance of the construction phase; (iii) oversight of the management and decommissioning activities; (iv) the review and approval of studies about hydro-geological requalification; and (v) the preparation of practical documents and guidelines.

[54] Since 2006, the Italian Registry of Dams (*Registro Italiano Dighe*) – the main body in charge of dam management and oversight at the national level – was dismantled, and its competences were transferred to the Ministry of Infrastructure and Transport.

[55] Between 1988 and 2007, coastal subsidence has significantly decreased, moving from an average of 3 cm/year to 2 cm/year (Romagna Acque - Società delle Fonti, 2007[114]).

[56] Chemical conditions are assessed by monitoring the concentration levels of chemical pollutants in water. Ecological conditions are assessed by monitoring water ecosystem functionality. For water courses, any hydro-morphological alterations – ad their potential impacts on water ecosystems – are also assessed (ARPAE Emilia Romagna, 2016[113]) (ARPAE Emilia Romagna, 2021[123]).

[57] The report contains comprehensive recommendations on dam building and provides a framework for addressing the negative environmental impacts of dams (World Commission on Dams, 2000[131]).

5 Conclusions and recommendations to mainstream green infrastructure and nature-based solutions in Italy

Despite recent efforts to promote sustainability considerations in public investment decisions, green infrastructure (GI) and nature-based solutions (NbS) are not yet fully integrated in spatial planning and projects' appraisal instruments in Italy. For this reason, the OECD has developed a series of recommendations to promote the integration of GI and NbS in infrastructure governance in Italy. The recommendations build on international good practices and 3 main pillars: 1) creating an enabling policy and regulatory environment for the consideration and uptake of GI and NbS; 2) defining clear institutional roles and responsibilities, and establishing co-ordination mechanisms to boost collaboration among the actors responsible for GI planning and implementation of NbS; and 3) building a knowledge-base and technical competencies for planning and implementation of GI and NbS across all levels of government

5.1. Create an enabling policy and regulatory environment for the consideration and uptake of green infrastructure and nature-based solutions

Italy has a comprehensive policy and regulatory framework to promote the sustainability of infrastructure in the country. This framework is centrally initiated, but also includes specific instruments for local and regional infrastructure projects. Good examples are the sustainability requirements connected to the DNSH principle and climate risk and vulnerability assessments in the PNRR, which require environmental sustainability in order to allocate funding to infrastructure projects.

However, while Italy certainly has good sustainability requirements for infrastructure plans and projects, the notion of sustainability does not explicitly consider GI. Although indicators such as mitigation of greenhouse gases, noise and vibrations, and biodiversity are usually considered in infrastructure planning and appraisal, infrastructures' impact on ecosystem services, whether positive or negative, is not yet an integral part of the Italian policy-making practice. The Italian government could benefit from the creation of a policy and regulatory environment for the consideration and uptake of GI in infrastructure planning and NbS in project planning, including the full consideration of the ecosystem and long-term benefits that they have to offer.

The following recommendations are proposed to improve Italy's policy and regulatory environment for the integration of GI and NbS:

- **Promote a cultural paradigm shift to enhance the consideration of GI and NbS**: in the Italian infrastructure sector – including public building, housing, urban planning, mobility, etc. – most stakeholders have traditionally considered NbS exclusively as decorative or additional to grey solutions. Nowadays, this approach is gradually changing; infrastructure designers and developers and urban and landscape planners are increasingly considering NbS as core assets able to deliver significant benefits. Nonetheless, this transition is in its early days. There is still a long way to go to fully consider NbS as part of infrastructure projects, or even GI, as core solutions to today's climate, biodiversity, social, and economic challenges. An example where this could be observed is in the Bicocca-Catenanuova railway, where individual NbS have been added, but the full potential of GI has not yet been exploited because the full benefits of using GI to enhance and connect nature areas are not yet integrated into spatial strategies of the region. Therefore, it is critical to mainstream GI and NbS use in key national policy strategies such as Nationally Determined Contributions, Adaptation Communications, and greenhouse gas emission reduction strategies, as well as in sectoral policies and strategies.
- **Define an integrated policy framework for GI and NbS**: the existing proliferation of "green" strategies and policies – both at the national and sub-national level – can generate confusion and lead to inaction, especially for regional and municipal administrations that do not have enough capacity to keep up with the expanding set of these strategies and policies. Moreover, sub-national actors often lack awareness of GI, and the absence of central-level guidance makes planning, implementation and monitoring of GI and NbS even more challenging. For this reason, it is important to define a national strategy specific to GI and NbS, which clarifies their benefits, their characteristics, the underlying challenges and trade-offs, and the available tools for implementation. A dedicated strategy would also be crucial to mainstream GI planning and NbS into sectoral strategies and policies and to ensure consistency and synergy across different green infrastructure projects and initiatives. The strategy should take into account the needs of sub-national administrations and their capacities to integrate the strategies into their policy-making processes, as well as the specific characteristics of each territory, as has been pointed out in the case study on Urban Regeneration in Bari.
- **Establish legislative and regulatory requirements to promote the adoption of GI/NbS** by public authorities and project designers and developers. This can be achieved by strengthening

existing public procurement strategies and regulatory frameworks to incentivise and promote the integration of NbS and GI in public investments. To this end, it is critical to either define new Minimum Environmental Criteria or refine the existing ones to promote and valorise NbS. One suggestion could be that MASE takes the initiative and works with all the key relevant stakeholders and involve those regions and municipalities with extensive experience implementing successful GI/NbS (for example, the cities of Bologna and Milan or the regions of Lombardy and Emilia-Romagna) and translate their experiences and lessons learned into Minimum Environmental Criteria. Another solution is to favour the use of green infrastructures with innovative solutions in the public tenders that involve significant changes in spatial planning.

- **Integrate GI and NbS considerations in the existing national and sub-national instruments for infrastructure appraisal**. Italy has multiple evaluation procedures which are currently used at both the planning (e.g. SEA) and the project level (e.g. EIA, EIS), and related appraisal tools (e.g. CBA, MCA). These instruments already include GI and NbS-related indicators, such as biodiversity, and identify impacts such as impacts on vegetation, soil, groundwater and fauna (see, for example, this report's case studies for the transport sector). The existing set of appraisal procedures and instruments should not be made any more complex. However, it could be adjusted to better consider GI and NbS. Moreover, the use of the instruments could be adjusted to fully grasp the long-term benefits of GI and NbS.
  - It is recommended to make ecosystem services an integrated component of infrastructure plans and regional spatial planning, so they can be properly assessed by a SEA, such as was suggested for SUMPs in this report's case study on Milan's M4, or for regional transport planning and spatial planning integration in the Bicocca-Catenanuova case study. The SEA should also explicitly assess the infrastructure planning's impacts on ecosystem services, and spatial planning that enhances these services, e.g. by creating large green corridors with GI, should be preferred.
  - Additionally, NbS should be more explicitly considered in appraisal at the project level, for instance, ensuring that the project is enhances existing green areas, throughout the full project life cycle (thus including an impact assessment for the operational phase). Moreover, environmental impacts should be included in the CBA, as NbS are able to create monetary benefits over time, e.g. through recreation or avoidance of infrastructural failure induced by extreme weather events by NbS' ability for climate adaptation.
- **Strengthen sustainability and GI and NbS considerations in the evaluation framework recently developed by MIT to promote sustainable infrastructure**. This framework already includes attention to different dimensions of sustainability of infrastructure projects: economic and financial, social, environmental, institutional and governance (see chapter 4 for a thorough elaboration on the full evaluation framework). These sustainability elements are well-integrated over the full infrastructure life cycle, from planning to prioritisation and implementation. Therefore, the framework offers an excellent opportunity to integrate considerations throughout the full infrastructure life cycle. The fact that the framework also includes updated guidelines on ex-ante evaluation of public projects makes it even more appropriate, as it provides an excellent tool to fully grasp the benefits of NbS and select the project that best enhances ecosystem services. However, the framework could still use more explicit consideration of GI and NbS. Therefore, it is recommended to define KPIs for GI for infrastructure planning and for NbS for project appraisal, such as climate resilience, continuity of biodiversity, fragmentation of habitats, and total surface of natural areas in the proximity of the infrastructure, as was also mentioned as recommendation in the case study for the Bicocca-Catenanuova railway line.
- **Establish economic and financial incentives to promote the use of NbS by public authorities and project designers and developers**. Financial incentives to adopt NbS in infrastructure projects can help strengthen the business case and facilitate decision-making. The economic and

financial instruments can take the form of subsidies and payments, grants, tax reliefs and exemptions, insurance and as well as risk transfer mechanisms, and other fiscal policies. Proper legislation and regulations must be put in place to support economic and financial incentives for NbS projects. In addition, to change the current predominance of public financing for NbS, it also needs greater private sector involvement through innovative economic and financial instruments

5.2. Define clear institutional roles and responsibilities, and establish co-ordination mechanisms to foster collaboration among the actors responsible for GI planning and implementation of NbS

The current institutional set-up governing GI in Italy is puzzling. Many actors are involved in planning and implementation - both at the national and sub-national level -, but their roles and responsibilities often overlap. **Defining a common reference framework that assigns clear tasks and responsibilities to the relevant players is key**. It helps to clarify the main processes, actions, and actors that are necessary for the effective design and implementation of GI.

Moreover, currently there exists just a few opportunities for this wide range of actors to meet and exchange, and this represents another obstacle. Co-ordination is important to promote coherence and synergy across the different initiatives relevant for GI, as well as to address the trade-offs between them, where necessary. GI planning and implementation build on regulations, policies and actions that go beyond a single agency's responsibility, and green infrastructures often cross sectors, territories, and jurisdictions. For this reason**, a cross-sectoral and cross-governmental approach** is needed to raise awareness, enhance technical capacity, as well as to improve the policy and regulatory environment.

Given these premises, these are the suggested recommendations for Italy to improve the institutional arrangements governing GI planning and implementation:

- **Central-level institutions, such as MIT and MEF should start promoting more actively ecological connectivity, protection of biodiversity and ecosystem services in their policy and financing instruments**. This is essential to ensure the alignment of the actions (e.g. projects, policies, regulations) taken by other national and sub-national actors, especially those involved in land-use and territorial planning.

  To date, MIT has not taken full advantage of its leading role to support the integration of GI in infrastructure and territorial development. GI should be mainstreamed in all the policies and regulations of the Ministry, and projects' impacts on ecological connectivity, biodiversity and ecosystems should be considered and inform the allocation of funds.

  MEF also has an important role to play. The ministry is responsible for coordinating and planning public investments, and it could start promoting GI and NbS through its financing instruments. For example, it could make public financing conditional on the integration of considerations relevant for GI in public investments projects. Effective financial schemes can also incentivise the economic contribution by private actors to scale-up available finance for NbS. These can include land stewardship or payment for ecosystem services schemes.
- **Develop horizontal co-ordination mechanisms, both at the national** (i.e. across ministries) **and sub-national levels** (i.e. across regional, provincial, and local administrations). This is particularly important as GIs often cut across jurisdictions and sectors. At the central-government level, Italy should provide platforms where the different ministries (e.g. MIT, MASE, MoC, MASAF) and other key stakeholders specialised in climate and environmental issues (e.g. ISPRA) can meet, exchange knowledge, and inform sectoral policymaking (i.e. biodiversity, water resources, transport, energy, etc.). This ensures coherence and synergies across sectoral initiatives and helps bringing silos and addressing potential trade-offs in a more comprehensive and effective way. This

is particularly relevant as GIs are most effective when integrated into comprehensive plans (Ozment, Ellison and Jongman, n.d.[1]). One solution could be to refine existing co-ordination mechanisms and institutions, for example CIPESS or the PINQuA's High-Commission, to extend the participation to all relevant actors (e.g. including MASE and ISPRA in the PINQuA's High-Commission) and pay more attention to matters related to GI, such as ecological connectivity and biodiversity protection.

At the sub-national level, it is also important to develop co-ordination mechanisms and platforms for regional and local authorities, especially for land-use and territorial planning. GI cannot be sustained by managing individual sites in isolation, as their associated benefits (e.g. protection, restoration, and enhancement of ecosystem services) often depend on processes taking place on a larger scale. To ensure GI reach the expected results, it is necessary to take a wider perspective and coordinate with other administrations operating across the national territory. This promotes coherence and synergies between sub-national regulations and plans for territorial development, as well as between individual infrastructure projects.

- **Develop vertical co-ordination mechanisms.** Sub-national administrations are critical drivers of GI planning and implementation. They can promote GI through regulations and strategies (e.g. land-use plans, building regulations, plans for territorial development, urban development strategies, etc.) and they are often responsible to carry out individual infrastructure projects. It is thus important to ensure their initiatives align with the strategic objectives defined by central-level ministries, especially MIT. This can be achieved in three main ways, which are not mutually exclusive: (i) Through funding mechanisms. For example, funds by MIT for sub-national infrastructure projects should be provided on the condition that projects align with GI criteria and strategic objectives. (ii) Through technical support. Under the existing framework, ARPAs are involved in the environmental assessment of sub-national plans for territorial development and individual infrastructure projects. They can take advantage of this role to strengthen considerations relevant for GI, such as plans' impacts on biodiversity and ecosystem services and their potentials to strengthen ecological connectivity across existing green and protected areas. (iii) Through strengthened environmental monitoring. Environmental monitoring of plans and projects is often disregarded, but it is key to ensure plans and programmes comply with the recommendations identified in the SEA/EIA process, as well as to identify in a timely manner unexpected environmental impacts (e.g. loss of animal or plant species, disruption of ecosystem services, land or habitat fragmentation) and intervene with corrective actions to safeguard ecological connectivity.
- **Engage non-government actors and define their roles and responsibilities.** Non-governmental actors can be engaged at different stages of the process, from planning to financing to implementation. Private actors (e.g. private landowners such as farmers) can contribute to funding NbS, and citizens, urban planners, and designers can be involved in the design process (i.e. co-design approach). For example, public administrations responsible for the implementation of NbS can launch consultation initiatives with the local community, offering citizens the opportunity to share proposals and actively contribute to the design of NbS. As in most Italian metropolitan cities available surfaces to host NbS are missing, co-operation with the private sector and citizens can offer new opportunities to make space for nature, for example by greening existing grey infrastructures (e.g. through green roofs) or de-sealing currently sealed surfaces. Moreover, local communities have often an important role in the long-term maintenance and sustained performance of NbS (e.g. urban farming, green urban spaces, green walls, etc.).

  Collaboration with local actors also foster awareness raising, information exchange and new designs. It promotes the consideration of a wider set of needs, perceptions, and perspectives, which is important to make the final project effective. For this reason, Italy should promote ownership of NbS by non-government actors by engaging them from the very beginning (i.e. in the design phase), and throughout the entire decision-making and implementation process. This will

also help local communities and citizens to gain a good understanding of all the challenges and trade-offs involved in infrastructure planning and NbS projects.

Engaging local stakeholders in an efficient way requires the development of innovative tools and mechanisms, as well as the definition of clear roles and responsibilities for non-government actors for NbS.

5.3. Build a knowledge-base and technical competencies for planning and implementation of GI and NbS across all levels of government

Information plays a key role in identifying new opportunities and triggering action for the integration of GI NbS. Italy seems to suffer from different levels of knowledge-base and technical capacities among people working in different levels of governments. Uncertainty around these solutions bring us to turn in favour of traditional grey infrastructure so it's fundamental in the Italian context to generate and disseminate information on GI and NbS performances where they are still not well known. Information on their maintenance needs and on their effectiveness over time is crucial for their development and for their consideration in Italian planning and design processes conducted by local governments. There is also a need to spread information on hybrid solutions, when green elements complement traditional engineered solutions or grey infrastructures. Italy misses tools to well communicate and disseminate the available information on existing projects, good practices and performance data to support policy makers and urban planners in the use of GI and NbS and improve their consideration in the decision-making process.

To successfully plan and develop measures to address climate and environmental risks, public and private stakeholders rely on existing technical information. Italian actors need to be aware of GI and NbS potential and limitations on their territory. Before thinking about new solutions, it's fundamental that Italian authorities and agencies develop specific analysis on the natural assets of the Italian territory, map the risks local territories need to face consider how future scenarios could affect the effectiveness and existence of nature-based-solutions and GI and build methods to monitor their life cycles.

The following recommendations are proposed to improve Italy's knowledge and technical capacities on GI and NbS:

- **Understand natural assets and how GI and NbS can be better integrated in the territory (cost-benefit analysis).** Technical information related to existing ecosystems is crucial to design GI and NbS that are most appropriate to the territory. Even if evaluating the natural resource stock of a country is not easy as it seems, Italy could develop an **inventory of natural capital and assets** that can help estimating the values of GI and NbS services and benefits they could provide if implemented in a specific area taking into consideration its natural characteristics. For example, the United Kingdom performed a National Ecosystem Assessment and wrote guidelines on how to apply the natural capital approach in decision making processes to be sure that natural strengths play a role in the analysis conducted ex-ante during the infrastructure planning phase. Additionally, in Italy there is a need of building awareness of green elements' strengths and limitations to better adapt them to a specific natural habitat. Developing **new indicators** to assess and measure the benefits and costs of green infrastructures and NbS can help future policy makers and urban planners in the design of new interventions. Information on positive and negative **environmental impacts** of these interventions needs to be included in the above cost-benefit analysis in order to fully consider their relevance, costs and benefits over their lifetime, e.g. the repopulation and growth of economic activities induced by the presence of a strategic GI and so on. Italy could also consider **involving universities and academia** in helping with cost-benefit analyses given their experience on that and promoting the work they are conducting. As an example, the School of Architecture Urban Planning Construction Engineering at the Politecnico of Milan published a catalogue on NbS for urban regeneration and Stanford University developed a model called

InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) which maps and values goods and services from nature and helps to quantify trade-offs and identify natural environments that can most benefit from investment in order to enhance natural capital and deliver ecosystem services.

- **Enhance data on existing ecosystem for effective GI and NbS planning and implementation.** Information on the location, composition and condition of ecosystems could help in GI/NbS planning and implementation across all levels of government. This information can facilitate the assessment of the suitability of green elements in specific places, as well as the monitoring of project impacts. At the same time, these data are also critical to avoid maladaptation, e.g. by avoiding using invasive or non-native species that can disrupt local ecosystems or enhance climate risks (e.g. planting flammable vegetation in fire-prone areas). To achieve this technical knowledge, Italy could create and maintain national and sub-national **ecosystems databases & maps which can serve as a basis for policy makers and urban planners for project planning**. This means that Italy needs to invest in data gathering and monitoring of **geospatial** information on land cover and use types, green spaces, biodiversity hotspots, ecosystem connectivity, habitat fragmentation, etc. The Italian administration should also increase the involvement of **ISPRA** as it gathers environmental data on the national territory, including data on GI and NbS planning and implementation and develops guidelines and recommendations for public authorities and administration (both at national and sub-national level).
- **Understand future scenarios, including climate scenarios, and how these affect the effectiveness of GI and NbS.** In addition to information related to ecosystems, there is a need to inform policy makers and planners regarding future scenarios and climate risks to better understand where, why and how GI and NbS need to be planned and/or implemented. Italy could include **climate change risks maps** in the **National Adaptation Strategy** they are working on. In this way they can provide valuable information to local governments to help them understand the risks they need to face and on what risk they should focus. Italy is experiencing many natural disasters causing deaths and problems to the natural capital of the territory. To help decreasing these risks, Italian policy makers should start using scaled-down climate and **environmental scenarios** that represent projected **climate-related natural hazards** at the national and local level in combination with information on local exposures and **vulnerabilities** affecting the population and the natural ecosystems.
- **Monitor information on GI.** Information on the effects of NbS and GI is fundamental to ensure their effectiveness and to show the positive and negative impacts. However, benefits from GI and NbS can take years to show up. To help bridge this gap, monitoring should be a requirement in each strategy or plan related to infrastructure planning and implementation. In order to achieve this objective, Italy could **involve private actors** such as financial institutions and insurance company that can cooperate in monitoring these effects and helping in building a good knowledge of performance information. Moreover, Italian strategies on planning infrastructure could include **new indicators** which can feed into **risk and impact assessments**, to be undertaken at different stages of the project lifecycle and helping the monitoring process considering all aspects. These assessments should include ecological and climate impacts in the vicinity of the GI and NbS site to be more accurate, as well as on other ecosystems that might be affected.
- **Encourage the consideration of GI and NbS and improve technical capacity across all levels of government.** Technical knowledge among GI and NbS practitioners need to be strengthened. In particular, at municipal level, there seems to be a lack of technical competences on NbS, as well as widespread uncertainty about their effectiveness. Hence, local administrations often tend to opt for solutions, such as grey infrastructure, they are more familiar with. To help bridge this gap and raise awareness around this topic, Italy could encourage universities and technical/professional schools to **promote GI and NbS in education programmes** maybe involving the Ministry of Education in the discussion and mainstreaming the word also among them. This could force urban

planners' new generation to be aware of climate risks and new solutions that can help in facing new challenges. To encourage the consideration of GI and NbS among current practitioners, MIT should organize **compulsory training programmes**, with the help of **ISPRA or regional ARPAs**,for construction experts, employees of municipalities, regions, national authorities and private stakeholders involved in the implementation of infrastructure (the so-called "participated companies", such as MM Spa in Milan).

- **Compile best practices and performance data on the planning and implementation of GI and NbS.** To help raise awareness and build knowledge among policy makers and urban planners, Italy could edit **handbooks and technical guidance documents** with case studies showcasing successful practices making the case for NbS / GI (from other municipalities, regions, private actors) both on the Italian territory. This will help in showing evidence on GI/NbS effectiveness and provide practical examples. To increase the communication of these best practices, Italian ministries might want to develop **online platforms** to facilitate the knowledge exchange and help co-ordination among stakeholders at the national and local levels of administration. Promoting peer learning at both national and international level would be valuable. Italy could also further benefit from the already existing EU platforms on climate adaptation, GI, and NbS, to further scale up capacity building on the experience of other countries that may have faced similar risks (Climate ADAPT, Urban Nature Atlas, URBACT).
- **Create a National Competence Centre on GI and NbS.** This would be a real asset in the future development of these new solutions. Most notably, it could **connect** municipalities, key public and private stakeholders (such as environmental agencies, enterprises, academia, and community associations) and administrations at higher levels. It might be involved in helping with a lot of the recommendations listed above in order to increase information and technical competences among the Italian territory. Firstly, conducting a first **assessment of municipalities' needs** to understand their major challenges and guide the creation of toolboxes with the required information would be crucial since it can be the starting point to fill the knowledge gap existing among the key actors working on these subjects. After having done a preliminary analysis, the National Competence Centre could group the **relevant datasets, tools, handbooks, websites, platforms** needed to have a solid information base and create a good **communication strategy** to share them with policy and decision makers, urban planners, GI and NbS practitioners. In a later stage, it might also be useful at the ministry and government as an advisory body that might help in developing new strategies and laws.

Reference

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OECD Public Governance Reviews

Developing an Integrated Approach to Green Infrastructure in Italy

This report provides an overview of green infrastructure planning and the use of nature-based solutions in Italy. It identifies key challenges and trade-offs and provides recommendations to promote their uptake across the different levels of government. The report also analyses four case studies that have been identified in agreement with the Italian Ministry of Infrastructure and Transport: the Green Node in Bari, the metro line M4 in Milan, the Ridracoli Dam in Emilia-Romagna, and the railway line Bicocca-Catenanuova.

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