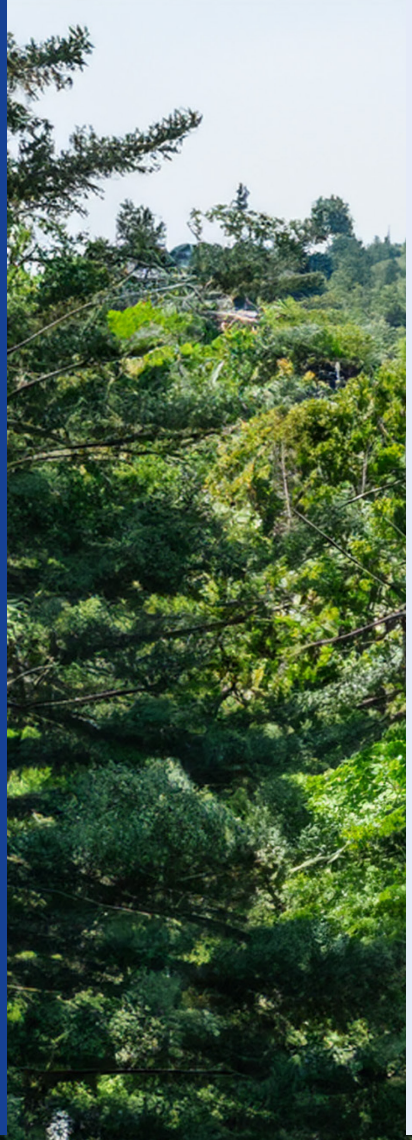

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FINAL REPORT //

ESPON GILL

Methodology for Quantifying the Demand for Green Infrastructure at Local Level

Main Report // February 2026

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Disclaimer

This document is a final report.

The information contained herein is subject to change and does not commit the ESPON EGTC and the countries participating in the ESPON 2030 Cooperation Programme.

The final version of the report will be published as soon as approved.

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Acronyms and abbreviations

BISE	Biodiversity Information System for Europe
CICES	Common International Classification of Ecosystem Services
ERDF	European Regional Development Fund
ESPON	European Observation Network for Territorial Development and Cohesion
ESS	Ecosystem Services
EU	European Union
GCP	Greening Cities Partnership
GI	Green Infrastructure
GIS	Geographic Information System
INCA	Integrated system for Natural Capital Accounting
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
LAU	Local Administrative Units
NbS	Nature-based Solutions
NRP	National Restoration Plans
NRR	Nature Restoration Regulation
OSM	OpenStreetMap
SHC	Stakeholder Consultation
SUDs	Sustainable Urban Drainage Systems
UAEU	Urban Agena European Union
UGP/UGP+	Urban Greening Plan/Urban Greening Plan Plus
UGS	Urban Green Spaces
UHI	Urban Heat Islands
UNP/UNP+	Urban Nature Plan/Urban Nature Plan Plus
WFD	Water Framework Directive

1. Introduction

In the context of accelerating biodiversity loss, intensifying climate change, and increasing environmental pressures, the implementation of green infrastructure (GI) and nature-based solutions (NbS) has gained increasing attention on the policy agendas of many municipalities in Europe. This trend is driven by the localisation of the European Green Deal and its strategies targeting climate adaptation, biodiversity protection, and nature restoration—most notably through the EU Biodiversity Strategy, the EU Climate Law, and the recent Nature Restoration Regulation (NRR). To effectively respond to these policy goals, it is essential for cities to have a **comprehensive understanding of the distribution of urban nature and the demand for it**. This knowledge is key to guiding targeted actions that support biodiversity, enhance climate resilience, and deliver multiple environmental and social benefits at the local level.

Against this backdrop, the **ESPON GILL project** aims to develop an **evidence-based, robust, scalable, and user-friendly methodology to guide policymakers and practitioners in quantifying the demand for Green Infrastructure at the local level**, thus supporting the delivery of Urban Nature Plans (UNP)[1] and other urban planning instruments. In particular, the ESPON GILL comes in direct response to Action 1 of the Urban Agenda's Greening Cities Partnership (GCP) Action Plan (2024).

To achieve this, TECNALIA Research & Innovation (TEC), the Institute for Urban Excellence (iUE), and the European Forest Institute (EFI) have formed a strategic partnership. Leveraging TEC multidisciplinary applied research expertise, iUE's international urban planning network, and EFI's wide knowledge in urban forest and landscape ecosystems, the ESPON GILL project aimed to foster resilient, climate-adaptive environments that support biodiversity, ecosystem services (ESS), and sustainable development, contributing to **improved urban planning and decision-making.**

Ultimately, the ESPON GILL project serves as a blueprint for future European Union (EU) policies, guiding cities towards greener, more sustainable living spaces by informing the development of urban plans, while also providing evidence to strengthen funding proposals.

ESPON GILL proposed a methodology for quantifying the demand for GI, which is based on the concept of GI as defined by the European Commission in its EU Green Infrastructure Strategy. It emphasizes the multifunctional, interconnected, and strategically planned nature of GI. It facilitates the **integration of GI and its associated ESS into planning processes** by linking biophysical data (e.g., land-use, GI delineation, and characterisation of GI components) with both quantitative and qualitative expert assessments of ESS provision, while also accounting for governance and socio-economic contexts.

ESPON GILL was **co-developed and tested in six case studies in Romania, Belgium, Finland, Poland, Italy and Croatia**, each representing different policy needs and varying levels of data availability. This collaborative approach aimed to demonstrate the applicability of GI and ESS-related information across different contexts.

The ESPON GILL Methodology is supported by a digital and user-friendly **User Manual**, which enables users to easily follow the different steps for quantifying GI demand in their municipality. The manual allows navigation through the modules, actions, and additional resources, either sequentially or in any chosen order. It is also linked to the **case study briefings**, providing access to their individual reports as well as to their **dashboards**, where the key resulting maps and their interpretation are presented.

In summary, the ESPON GILL project aims to directly enhance the ability of European urban authorities to substantiate the need for GI and meet the quantitative requirements from both EU and national policy levels, while ensuring that the evidence-based planning and implementation of GI directly benefits local communities.

[1] The accepted new term for Urban Greening Plans (UGPs).

*The present **ESPON GILL Final Report** present the key outputs from the project, namely the developed ESPON GILL Methodology, its testing and validation in six case-studies, the outputs ready for uptake (user manual) and present concluding reflections and remarks to inform both the uptake and scale-up of the ESPON GILL Methodology by urban authorities in Europe (and beyond).*

2. Executive Summary for Policy-Makers

Policy Context

In the European Union (EU), the urban landscape is heavily influenced by EU level decisions. The European Green Deal (EC, 2021), and its subset of policies, including the Biodiversity Strategy for 2030 (EC, 2020), sets ambitious targets for sustainability, climate neutrality and ecological restoration, which directly influence local governance, planning and development.

The role of local governments in implementing EU policies has been recognised, once more, in the new EU Agenda for Cities[2], which states that "local and regional authorities implement and use approximately 70% of EU legislation". For over a decade now, the urban dimension of EU policies has been informed and guided through the structured, multi-level framework of the Urban Agenda for the EU (UAEU), which promotes enhancing coordination between local, regional, national and EU authorities, whilst recognising that urban challenges cannot be addressed by cities in isolation but require alignment with EU strategies and funding instruments.

In recent years, considering the recently adopted Nature Restoration Regulation (NRR), the role of nature in cities has become a central focus, as illustrated by the establishment of the Greening Cities Partnership (GCP) of the UAEU. The NRR mandates the restoration of ecosystems and biodiversity, even within densely built urban areas (urban ecosystems).

Nature in cities not only supports biodiversity but also delivers a range of co-benefits that address multiple urban challenges, including air quality improvement, water management and climate mitigation and adaptation. As such, urban authorities are increasingly required to integrate interventions into their development plans, to not only support biodiversity conservation but also to improve urban resilience, address climate risks and ultimately, enhance the quality of life for residents.

Policy implications for urban authorities

In this context, urban authorities need to systematically assess their local demand for nature, a task that requires both an understanding of environmental concepts and the ability to quantify the services provided by ecosystems. At the core of this assessment is the concept of ecosystem services (ESS), which underpins the design and spatial allocation of green infrastructure (GI) as a solution to key urban challenges.

The GCP Action Plan, adopted in 2024, explicitly highlighted this need, noting that the ability to evaluate demand for GI is essential for accessing funding, particularly from the European Regional Development Fund (ERDF).

As defined in the EU 2013 Green Infrastructure Strategy, GI refers to a *strategically planned network of natural and semi-natural areas that deliver a wide range of ecosystem services*. In recent years, research and innovation (R&I) have expanded the knowledge to better understand, quantify and optimise the benefits derived from nature through the concept of Nature-based Solutions (NbS). By linking GI planning with ESS and NbS, urban authorities can design interventions that are both evidence-based and targeted to ensure that GI investments effectively address local challenges while providing multiple co-benefits in line with high-level sustainability goals.

[2] European Commission. An EU Agenda for Cities: Driving Growth and Prosperity (COM (2025) 739 final), EUR-Lex CELEX 52025DC0739, 3 December 2025.

Why action is necessary

While the call to action is clear, urban authorities face several operational issues when aiming to develop evidence-based investment plans for nature:

- Guidance, fragmented powers and responsibilities with regards to GI implementation are fragmented.
- The mainstreaming and integration of the ESS concepts from research into local planning remains complex due to data requirements and methodological sophistication.
- Urban authorities lack robust, standardised data to claim and prioritise GI investments effectively, notably as part of the ongoing programme period (2021-2027) for EU funding.

Several research and innovation (R&I) projects, including the Horizon projects CLEARING HOUSE and Urban Nature Plans+ (UNP+), are exploring how nature can be systematically integrated into urban planning instruments; however, mainstreaming these approaches beyond the R&I context, notably through Cohesion Policy and territorial instruments, is essential to achieve lasting and large-scale impact.

Under the next EU budget (Multiannual Financial Framework for 28-34[3]), the proposed thematic scope of the European Regional Development Fund (ERDF)[4] explicitly supports investment in NbS. Whilst the negotiations between the Council of the European Union and the European Parliament are still underway, preparations for the 28-34 ERDF Operational Programmes by the management authorities, including the identification of key investment priorities, is set to begin soon. The coming two years will therefore be critical for urban authorities to strengthen their knowledge and their capacity to develop evidence-based investment plans for nature, that are eligible for EU funding.

What ESPON GILL offers

To address these gaps and support the translation of high-level EU policy commitments into local planning tools, the ESPON GILL Methodology proposes to equip urban authorities with a practical stepwise framework to assess the demand for nature, prioritise interventions, and inform the development of investment-ready GI strategies.

A step-by-step approach for urban planners: structured in six modules, the ESPON GILL Methodology aims to support local decision-making with spatially relevant outputs for GI development aligned with local policy goals. The ESPON GILL Methodology is accessible through an interactive online tool (User Manual), complemented by a set of additional resources.

A review of existing ESS evaluation approach: selected and tested approaches to evaluate a set of key ESS linked to urban challenges, with alternatives based on spatial scale (urban/landscape) and data availability.

Six Case Study Reports: providing a practical demonstration of the implementation of the ESPON GILL Methodology for different contexts and urban challenges.

Complementary resources to guide urban authorities: outline of key EU policies, overview of main data sources, set of good practices.

[3] European Commission. A dynamic EU Budget for the priorities of the future: The Multiannual Financial Framework 2028–2034 (COM (2025) 570 final/REV1), EUR-Lex CELEX 52025DC0570R (01), 16 July 2025

[4] Article 4(1) in European Commission. Proposal for a Regulation establishing the European Fund for economic, social and territorial cohesion, agriculture and rural, fisheries and maritime prosperity and security for the period 2028-2034 and amending Regulation (EU) 2023/955 and Regulation (EU, Euratom) 2024/2509 (COM (2025) 565 final; CELEX 52025PC0565R (01)), 17 July 2025.

Policy relevance

Beyond a technical methodology, ESPON GILL addressed key policy needs from urban authorities:

- A need for **improved policy coherence**: urban authorities need structured guidance to align municipal planning with broader European objectives while ensuring coordination across governance levels.
- A need for **improved policy integration**: urban authorities require operational guidance to mainstream R&I concepts into everyday city planning and investment decisions as ESS concept remains disconnected from practical urban planning.
- A need for improved **policy effectiveness**: to effectively address local environmental and social challenges, urban authorities need evidence-based approaches to identify priority areas for intervention, map demand for GI, and inform their planning choices.
- A need for improved **policy efficiency**: with limited resources available, urban authorities need a structured methodology to help reduce experimentation, streamline decision-making, and ensure that investments deliver benefits where most needed.
- A need for improved **policy legitimacy**: in linking local action to EU-level commitments, urban authorities can ensure their investment plans are not only technically sound but also politically and socially supported.

The ESPON GILL methodology addresses all these aspects by providing a practical, operational tool that enables evidence-based planning, prioritisation, and investment in GI, supporting cities in implementing NbS in a systematic, targeted, and policy aligned manner.

3. ESPON GILL Framework

3.1 Green Infrastructure

Green Infrastructure is a key feature of ESPON GILL Methodology, and so are its definition and its classification into different typologies. However, the terminology may be wide and complex, so that as part of the project development, we aimed at defining what we understand by GI in this project, as well as what spatial elements we consider as GI[5]. It is important to note that within ESPON GILL, whenever the terms NbS and GI are used, they are intended to encompass a broad approach that also includes blue infrastructure (i.e., Green and Blue Infrastructure).

Considering the EU-wide definitions and their general applicability, and after a series of interviews with municipalities from the case studies and (where applicable) representatives of their national or local governments, we concluded that there is a general lack of consistent and coherent understanding from the local perspective of what constitutes GI, which in some cases does not even exist.

Therefore, and for facilitating the understanding on the terminology in a wide sense, **ESPON GILL use the definition included in the EU Green Infrastructure Strategy**, **where GI is defined 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.*"**. This definition highlights three essential aspects for its effectively integration into sectoral policies: connectivity, multifunctionality, and the integration with Spatial Planning and Management. In ESPON GILL, the qualitative analysis of the GI – such as measuring connectivity from physical, ecological or functional perspectives – is beyond the scope of the project, which is instead primarily focused on its quantification. However, methods for calculating connectivity are available through specific links included in Annex 2.5 (List of tools to support spatialisation of GI demand, GI provision and GI unmet demand).

It is therefore important to note that ESPON GILL places its emphasis on the mapping and quantification of natural and seminatural areas (both nodes and links) that form the backbone of GI. These constitute the basis for identifying gaps and potential ecological corridors, which shape GI as a coherent network.

The GI typologies considered in the ESPON GILL Methodology (Annex 2.6.) results from a compilation of classifications from both the EU FP7 GREENSURGE project and the Biodiversity Information System for Europe (BISE). These typologies are presented in the following list (Table 3.1).

Table 3.1
Typology of Green Infrastructure

Key GI Categories	Key sub-categories
Building Greens	Balcony green Ground based green wall facade-bound green wall Extensive green roof Intensive green roof Atrium Green pavements and green parking pavements
Urban Green areas connected to grey infrastructure	Green fences and noise barri- Tree alley and street Street green and green verge House garden Railway embankment Green playground/school Green parking areas Riverbank green areas Large urban park

[5] For clarification, whenever the terms NbS and GI are used in ESPON GILL, they are intended to encompass a broad approach that includes blue infrastructure (i.e., Green and Blue Infrastructure).

Key GI Categories	Key sub-categories
Parks and Formal Greenspaces	Historical Park/garden
	Pocket Park/parklet
	Botanical garden/arboreta
	Zoological garden
	Neighbourhood greenspace
	Institutional greenspace
	Cemetery and churchyard
	Green sport facility
	Camping areas
Semi Natural Greenspaces	Forest
	Shrubland
	Abandoned and derelict areas with patches of wilderness
	Rocks
	Sand dunes
	Sand pit/ quarry/ opencast
	Allotment

Key GI Categories	Key sub-categories
Allotments and com-Agricultural land	Community garden
	Arable land
	Grassland
	Tree meadow/orchard
	Biofuel production/agrofor-
	Horticulture
Green areas for water management	Rain gardens or SUDS
	Swales/ filter strips
Blue spaces	Lake/pond
	River/stream
	Dry riverbed
	Canal
	Estuary
	Delta
	Sea coast
	Wetland/bog/fen/marsh

In addition to the definition of the GI typology, ESPON GILL aimed at ensuring alignment with regulatory frameworks, policy goals, and public interest. For that, some **Common Objectives for GI** were identified (Annex 2.1) by assessing **how GI contributes to environmental quality, climate resilience, and equitable access, analysing its policy relevance at European, national, and local levels**.

At the **European level,** key GI-related directives, regulations, and strategies were reviewed (e.g., NRR, EGD, Biodiversity and Adaptation Strategies, Water Framework Directive (WFD), Cohesion Policy). These highlight their significance in terms of GI, and the ESS to which they most directly contribute to (carbon sequestration, thermal regulation, biodiversity enhancement, and soil and water management).

At the **national level**, case study analyses were conducted for the countries of our six case studies – Romania, Belgium, Italy, Croatia, Finland, and Poland – examining their policy frameworks, responsibilities for GI implementation, and availability of georeferenced and environmental data. While most countries recognize GI within strategic or legislative frameworks, the degree of integration and data use varies significantly.

At the **local level,** the analysis centred on the NRR, which introduces binding restoration targets for urban ecosystems, including maintaining and expanding green spaces and tree canopy cover by 2030 and beyond. The results highlighted how the ESPON GILL Methodology could directly support Member States and local authorities in mapping urban ESS and GI.

At the local level, different planning instruments have been produced by local governments related to GI deployment, such as urban forest plans, urban tree plans, GI plans, green infrastructure plans, and more recently UNP. This collection of instruments may provide valuable insights and inspiring ideas for defining the demand of GI. Based on a scan of plans published by cities in various regions, **a searchable Repository of Good Practice Plans for Urban GI implementation was built in ESPON GILL** (Annex 1.3).

3.1 Ecosystem Services

The selection of Ecosystem Services (ESS) considered for further guidance (and materialised in Annex 2.7 of the ESPON GILL Methodology) is based on a combination of conceptual, methodological, and operational criteria.

First, the selection was aligned with the objectives of Action 5 of the **EU Biodiversity Strategy** (Maes et al., 2013), *Knowledge of ecosystems and their services* – that although would require an update – aims to improve the understanding, assessment, and scientific knowledge of ecosystems and the services they provide (EC, 2011).

Considering this framework, and revisiting the ESS assessed in **ESPON GRETA** project, the ESS list of options has been reduced, considering those: (i) relevant for urban contexts, (ii) with available data, and (iii) methodologically feasible for assessment. As a result, *flood mitigation* and *carbon storage and sequestration* were selected.

Besides, **relevant recent scientific and policy-related initiatives** support the selection:

- The results of the workshop between the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (**IPBES**) and the Intergovernmental Panel of Climate Change (IPCC)
- The importance of the triple planetary crisis based on the interconnections between biodiversity loss, climate change and environmental pollution – stressed by the in 2022 United Nations Framework Convention on Climate Change - UNFCCC
- The alignment with the urban ESS addressed by the EU Nature Restoration Law that has the mandate of no-net loss of green spaces by 2030, followed by a net increase in urban green space and a minimum of 10% tree canopy cover by 2050. These targets call for enhancing biodiversity, climate regulation (heat reduction), air purification, flood mitigation, and overall public health and well-being.

Additionally, the **explicit prioritisation of ESS by the ESPON GILL Case Studies** has also led to the final delineation of the definitive selection. The choice of three priority ESS (discussed in the SHC2) was common for all case studies:

- *urban heat regulation* (link: ESS related to cooling)
- *availability of green spaces for recreation, social interaction, equity and health* (link: ESS related to recreation/human health/wellbeing)
- *biodiversity enhancement*

Although *biodiversity enhancement* was identified as highly relevant and prioritised by all case studies, it was not included in the final analysis, given the strong dependence of urban biodiversity on site-specific design and management practices, the limited availability of European-scale data at a spatial resolution suitable for urban analysis, and the excessive complexity of modelling required, not aligned with the scope of this study.

Overall, the ESS finally included in ESPON GILL are supported by the academia, align with policy objectives, and respond to the needs of the municipalities which face the challenge to design, plan and manage GI in practice. These ESS are also those that can be addressed from an urban planning and management perspective, in line with the distribution of competences and responsibilities.

In the case of biodiversity, which operates at a broader territorial landscape scale, its management requires the involvement of other levels of public administration that go beyond municipal authority. In any case, it is assumed that a healthy and well-connected urban GI will have a positive impact on biodiversity, regardless of whether these aspects have been explicitly included in the analysis.

It is worth noting that provisioning ESS was deliberately excluded from the analysis, as they largely depend on human inputs such as energy (e.g., labour, fertilizers) or capital (Nelson et al., 2009; Maes et al., 2012; EEA, 2014).

It is important to highlight that the ESS mentioned were specifically selected for development within the ESPON GILL Methodology, including references, technical annexes, modelling approaches, and related materials. However, this does not imply that other ESS cannot be considered or implemented following the same steps (e.g., landslides or air pollution, which were addressed in some case studies).

4. Setting the scene – Case Studies

One of the backbones of the ESPON GILL project are the case studies. The six proponent-stakeholders of this ESPON Targeted Analysis and along with the corresponding municipalities identified as case studies, are actively collaborating within the multi-governance framework of the GCP under the Urban Agenda for the EU. The case studies played a crucial role in shaping the ESPON GILL initiative by helping to set the context, identify key needs, provide relevant data, and validate the methodology. However, it is important to emphasize that the inputs contributed by the participating municipalities—whether in the form of analysis, expectations, or preferences—do not represent any formal or legally binding commitments.

ESPON GILL has supported the six committed territories in the development, delivery, and implementation of the ESPON GILL Methodology, which is intended to be transferable and applicable to other regions across Europe. This support consisted of multiple consultation and interaction, where the case studies teams were able not only to provide access to local knowledge, relevant documents, and data, but also to share their insights, provide guidance, compare their progress, and consequently to apply the method in their policy processes.

The municipalities assigned as the **Six Case Studies in ESPON GILL are: Târgu Mureș (RO), Roeselare (BE), Tampere (FI), Imola (IT), Jastrebarsko (HR) and Sopot (PO)** (Figure 4.1).

Their involvement was strictly voluntary and focused on testing the methodology in real-world settings to ensure its practicality, relevance, and effectiveness. This collaborative approach allowed for valuable feedback and insights, helping to refine the ESPON GILL Methodology so that it can be effectively applied by other municipalities across Europe.

The exchanges with the case studies teams were centralised in **three Stakeholder Consultations (SHC) organised along the project timeline** (26 March 2025, 23 September 2025, 22 January 2026), which provides the case studies teams with opportunities to exchange insights, compare progress, and apply the methodology effectively while assessing its feasibility with local stakeholders within their policy processes.

The **Baseline Analysis developed for each Case Study** results in an inventory of existing data (Annex 2.3) that may be useful to quantify the GI using the ESPON GILL Methodology. It includes both quantitative and qualitative data, compiled through desk research, enriched by the knowledge of the case studies teams. Although the complete baseline analysis is included in the individual Case Studies Reports, a summary of the data collected is presented in Table 4.1.

Figure 4.1
Distribution of ESPON GILL Case Studies

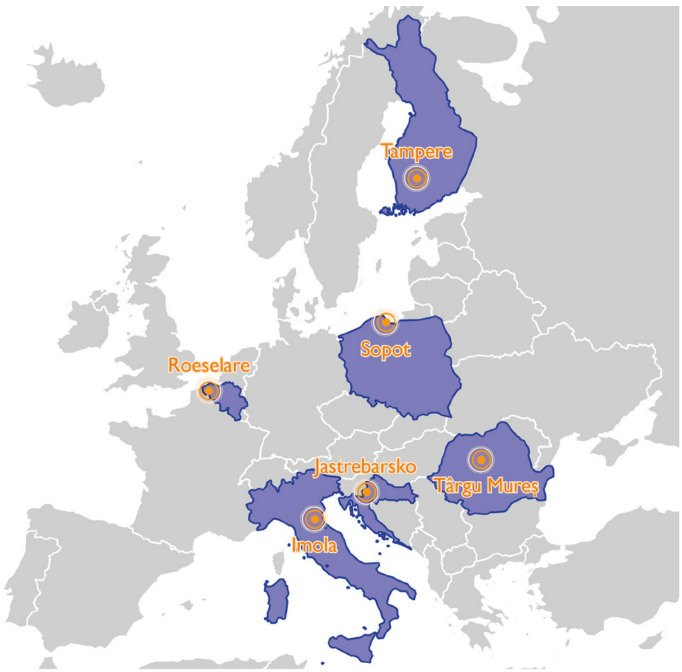


Table 4.1
Status of data collection

Data need	Imola (IT)	Roeselare (BE)	Jastrebarsko (HR)	Sopot (PL)	Tampere (FI)	Târgu Mureș (RO)
Information on Policy context	National Regional Local	National Regional Local	National Regional Local	National Regional Local	National Regional Local	National Regional Local
Study area defined	Regional Geoportal	Municipal boundary (Geoportal Vlaanderen)	Geoportal Jastrebarsko	City Geoportal	Central urban area – delivered by the city	Urban zone (Intravilan) - delivered by the city
Socio-demographic context	Regional Geoportal (online map); Metropolitan geoportal (shp)	Statistical sectors (Geoportal Vlaanderen)		City level population data from Bank Danych Lokalnych	Phased comprehensive plan analysis, incl. restricted data layers (on request)	Data available and retrieved, but not in spatial format
Spatial distribution of GBI at the local/territorial scale	Metropolitan geoportal; regional geoportal; requested to case studies; Open Street Map	Geoportal Vlaanderen (Greenmap Flanders 2021, Land-cover Plan 2022) Greenspaces managed by the city	Spatial Plan Jastrebarsko, Geoportal Jastrebarsko; Open Street Map; Statements from the local technical team	From city geoportal, From Urban Atlas Tree inventory, Hydrological data for BI	Tampere open WFS interface Phased comprehensive plan, data layers on request for restricted data	Green Space Inventory (RSV, only greenspace managed by the city and in the General Urbanistic Plan)
Map of accessible green space	Local data	Geoportal Vlaanderen (Greenmap Flanders 2021)	Geoportal Jastrebarsko; Open Street Map; Statements from the local technical team		No data available (areas managed by city, as indicated in the phased comprehensive plan is an alternative)	Green Space Inventory (RSV)
Biodiversity mapping	Regional Geoportal (not shapefile)	Geoportal Vlaanderen (BWK)	Bioportal	Tree species inventory	Restricted data on request, data layers of the specific study Keskustan ekosysteemi-palveluselvitys (2023) cover some aspects; +open forest data (Metsäkeskus) and environmental data (SYKE)	Only for selected sites
Locations of individual trees in the public domain	Regional geoportal	City of Roeselare	Geoportal Jastrebarsko; Open Street Map	Tree inventory	Tampere open WFS interface	Green Space Inventory (RSV)
Building footprint	Open Street Map; regional geoportal	Geoportal Vlaanderen (GRB)	Open Street Map, Geoportal Jastrebarsko	From city geoportal		General Urbanistic Plan (not city-wide)
Road network	Open Street Map	Geoportal Vlaanderen (GRB)	Open Street Map, Geoportal Jastrebarsko	From city geoportal	Tampere open WFS interface	Open Street Map
Mapping of ESS provision	Flood risks (among others) from regional geoportal	Many layers on Geoportal Vlaanderen, INBO Geoportal and VMM Geoportal (partly downloaded) (flood maps, UHI maps, potential recreation, ...)	Soil retention obtained from KIP INCA source; Recreation obtained from statements from the local technical team	Developed via InVEST	Restricted data on request, data layers for heath islands, stormwater management (NbS) and the specific study Keskustan ekosysteemi-palveluselvitys (2023)	Data from maps in reports, national or European data, Inundatii.ro for floodings (WFS)
Mapping of ecosystem conditions	Flood risks regional geoportal	Geoportal Vlaanderen (soil, flood control, water resources)	Soil loss obtained from KIP INCA source		Analysis in progress, e.g. Habitat types, but data available only later	Data from maps in reports, national or European data available, for floods: Inundatii.ro (WFS)
Current land-use at the local scale	Regional geoportal	Geoportal Vlaanderen (Land-use 2022)	Spatial Plan, Geoportal, ARKOD parcels, Cadastre, OSM, Statements from the local technical team	From city geoportal	Tampere land-cover from Tampere open WFS and SYKE interface (2022)	National data & OSM

Data need	Imola (IT)	Roeselare (BE)	Jastrebarsko (HR)	Sopot (PL)	Tampere (FI)	Târgu Mureș (RO)
Land-use scenarios	LUISA; regional geoportal	Municipal structure plan, Green Structure Plan		LUISA		
Identification of available spaces			Geoportal		Restricted data on request, data layers of the specific study Keskustan ekosysteemi-palvelusel-vitys (2023)	
Biophysical conditions		Geoportal Vlaanderen (soil, flood control, water resources)		Tree health inventory	Above mentioned studies might cover some aspects	See above (ecosystem conditions)
Planning documents	GI strategy projects (local); regional/metropolitan plans	Municipal structure plan, Green Structure Plan	Spatial Development Plan, Green Urban Renewal Strategy, General Urban Development Plan, Detailed Urbanization Plans	Local development plan	Phased comprehensive plan; Detailed plan (central urban area)	General Urbanistic Plan

Data identified and retrieved
Data identified and not retrieved (not relevant/required for the scope of the ESPON GILL Methodology testing)
No relevant data identified or retrieved

5. ESPON GILL Methodology

The ESPON GILL project offers a Methodology for Quantifying the Demand for Green Infrastructure at Local Level which is based on the concept of GI as defined by the European Commission in its EU Green Infrastructure Strategy. The ESPON GILL Methodology emphasises the multifunctional, interconnected, and strategically planned characteristics of GI, facilitating its integration and its associated ESS into urban planning processes. It links biophysical data—such as land-use, GI delineation, and characterisation of GI components—with both quantitative and qualitative expert assessments of ESS provision and demand, while also accounting for governance and socio-economic contexts.

The ESPON GILL Methodology encompasses (i) the definition of policy goals related to GI, (ii) the characterisation of existing GI and ESS provision, demand and unmet demand, and (iii) the integration of GI into urban planning to accelerate implementation.

This approach enables municipalities of varying capacities and resources to assess GI demand effectively, enhancing their ability to meet local policy goals as well as EU and national requirements. As a result, the ESPON GILL Methodology aims to:

- Create a context-related, scalable, and user-friendly methodology to quantify and communicate local needs for GI.
- Integrate this methodology into urban planning and policymaking processes.
- Facilitate the planning, implementation, and funding of GI and NbS in line with EU regulations.

5.1 Overall Structure

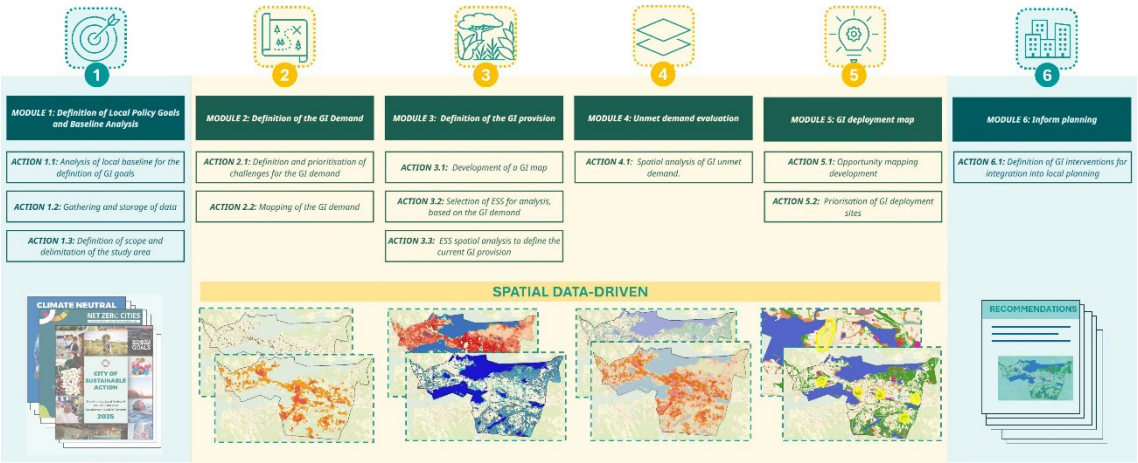
5.1.1 Characteristics of the ESPON GILL Methodology

The ESPON GILL Methodology is designed as a modular, flexible, and adaptable method that supports municipalities in its practical application. Its structure accommodates diverse local contexts, varying levels of data availability, and different policy ambitions, ensuring its relevance and usability across Europe.

Modularity

The methodology is organized into standalone yet interconnected modules, each addressing a key component of the methodological process (Figure 5.1). This modular structure enables users to apply the methodology either sequentially or independently, depending on local priorities, available resources, previous work, and policy objectives. Each module generates specific outputs that can inform subsequent modules, facilitate collaboration with municipal departments, and support engagement with external stakeholders and civil society.

Figure 5.1
Modules of ESPON GILL Methodology



This modular structure also enhances adaptability during implementation, offering practical entry points for integrating expert input and supporting an intuitive, context sensitive application of the methodology.

Scalability

The methodology is structured to be applied at two scales – urban and landscape – to ensure that GI assessment is adapted to different spatial contexts. This distinction is operationally necessary because GI types, the ESS they provide, and related challenges, may differ substantially between built-up and consolidated urban areas and the surrounding natural, rural or semi-natural areas. In addition, planning instruments, stakeholder involvement, data availability, and analytical approaches may also vary between these scales. Considering both spatial levels also allows the methodology to capture interactions between urban GI and the wider territory, such as ecological connectivity and functional linkages.

- Urban level: Focuses on built-up and consolidated urban landscapes containing GI, where the analyses are adapted to urban contexts. It may be defined differently from municipality to municipality.
- Landscape level: A spatial level of analysis that goes beyond urban limits, site-specific, local, or parcel-level analysis. This territorial delimitation is proposed to address natural and semi-natural areas beyond the urban core, including agricultural land, forests, and meadows, with the analyses oriented towards landscape-level ecological processes and functions.

Flexibility

The ESPON GILL Methodology is designed as a flexible framework that enables municipalities operating within different planning cultures and systems to adapt it to their specific contextual requirements.

The methodology is designed to be sensible to different contexts, capacities and resources. While some municipalities may have extensive access to Geographic Information Systems (GIS), ESS modelling, high resolution data on land uses, climate change scenarios and studies and biodiversity, etc others may face limitations in resources or data-processing capacity. Recognising that "one size does not fit all", the ESPON GILL Methodology adopts a tiered approach, allowing implementation to be adapted according to available resources (e.g., time, funding, existing data) and capacities (e.g., expertise, technical knowledge, institutional support). Municipalities can apply different tiers to individual modules, selecting outputs most relevant to their context, and adjusting the depth of analysis to match data availability, technical skills, and institutional capacity. This design ensures that the methodology can be applied across a wide range of contexts, from data- or resource-limited municipalities to those capable of supporting detailed, high-resolution analyses. The tiers are as follows:

- Seed stage: Intended for municipalities with limited access to high-resolution data, constrained time or funding, or restricted scientific or technical capacity. This tier focuses on essential assessments, using simplified analytical approaches, readily available datasets, and rapid evaluation techniques.

- Nature master: Designed for municipalities or institutions with greater capacity, resources, and data availability. This tier enables high-resolution analyses, integration of complex ecological processes, advanced modelling, and comprehensive assessment of ESS.

5.1.2 Components of the ESPON GILL Methodology

Modules

The methodology consists of six modules:

- Module 1 – Definition of local policy goals and baseline analysis: Establishes clear municipal GI goals by reviewing existing policies, developing new ones if required, compiling a centralised repository of relevant data, and setting the spatial boundaries and analytical level for the whole assessment.
- Module 2 – Definition of the GI demand: Identifies and prioritises the concrete challenges that GI can address, then translates these challenges into spatially explicit demand maps that show where and how strongly GI deployment is needed.
- Module 3 – Definition of the GI provision: Creates a comprehensive, standardized map of existing GI, selects the most relevant ESS to the identified demand, and quantifies the current provision of those services across the study area.
- Module 4 – Unmet demand evaluation: Compares demand and provision layers to pinpoint locations where there is a deficit of GI or its ESS output is insufficient, producing a map of unmet GI demand.
- Module 5 – GI deployment map: Generates an opportunity map that combines technical feasibility, contextual constraints, and stakeholder input, then overlays it with unmet demand information to rank and characterise priority sites for new GI interventions.
- Module 6 – Inform planning: Synthesises the preceding results into concrete, context-specific GI interventions and operational guidelines that can be directly embedded into local planning instruments, regulations, and design standards.

Each module contributes to the assessment and planning of GI by focusing on a defined thematic or functional objective. Modules can be implemented independently or in sequence, depending on local priorities, available resources, and prior analytical work. Each module consists of a set of actions that guide users from defining objective to producing concrete outputs. The module introduction outlines:

- The **aim of the module** and its role within the overall methodology.
- The **sequence of actions required** to achieve the defined aim. The action list provides a concise explanation of the actions to be undertaken, helping municipalities understand how each module can address their interest.

Actions

Actions are the operational units of the methodology. Each module contains between one and three actions, each translating the module's aim into practical analytical or planning tasks, ensuring consistency while allowing flexibility in implementation. For each action, the following elements are specified:

- **Objective:** Clearly states the intended outcome of the action and its contribution to the overall module´s aim.
- **Data input:** Identifies the data required to carry out the action, including preferred datasets and possible alternatives depending on availability. It also specifies which results from previous actions need to be incorporated.
- **Key activities:** Describes the main tasks to be undertaken, providing a structured overview of the process and establishing links to previous modules or actions when necessary.
- **Methods that could be used:** Indicates suitable methods that can be applied, allowing adaptation to different technical capacities and needs.
- **Expected results:** Defines the outputs produced by the action, such as analysis, maps, indicators, datasets, or assessments.

- **Checklist:** Provides a concise list of verification points to ensure the action has been completed consistently and to an appropriate standard. The checklist also indicates which outputs correspond to the **Nature master** tier.
- **Recommendations from practical implementation:** Offers implementation-oriented guidance based on practical considerations, supporting efficient application by municipalities and practitioners.
- **Additional resources:** Supporting materials, tools and datasets associated to the specific task, developed to assist implementation or enable more advanced analyses.

5.1.3 Pre-implementation Considerations

The ESPON GILL Methodology adopts a hybrid approach that combines spatial, data-driven methods (Modules 2 to 5) with planning-oriented processes, while also acting as a bridge between statutory and non-statutory planning procedures (Modules 1 and 6). This hybrid structure also offers opportunities for implementation through collaborative arrangements, including the involvement of external expert actors, such as universities, research institutes, and other knowledge partners.

Considering this hybrid nature, several processes should be considered during the implementation of the methodology from both data-oriented and planning-related perspectives. The timing and way these processes are applied may vary across municipalities, depending on factors such as data availability and data infrastructure, internal administrative capacities, and external governance arrangements, including stakeholder engagement processes.

The following general recommendations are intended to guide the implementation of the ESPON GILL Methodology and should be considered throughout the entire methodology implementation, ensuring coherence and consistency across all modules.

Quantitative and qualitative approaches

The ESPON GILL Methodology should be implemented through a balanced combination of quantitative and qualitative approaches. This integration is essential to ensure both analytical robustness and contextual relevance across different territorial and data environments.

- **Quantitative approaches** are appropriate where measurable and spatially explicit data are available. These may include existing indicators, GIS-derived layers, or other datasets (e.g. hazard maps, imperviousness data, accessibility indicators, or exposure and vulnerability indices). Quantitative methods can include threshold-based classifications, statistical ranges, or index values assigned to GI.
- **Qualitative approaches** are used to complement quantitative analysis, particularly where spatial data are limited or where local, context-specific knowledge is needed. These approaches may draw on expert knowledge, stakeholder input, participatory mapping, or descriptive assessments, and may result in expert-based knowledge or stakeholder-informed judgements.
- **Combined quantitative and qualitative approaches.** Quantitative results can be interpreted and validated using expert and stakeholder knowledge, while qualitative assessments can be supported by available spatial data. Depending on the data context, assessments may rely more strongly on one approach or the other but combining both can help improve the relevance and robustness of the results.

Data preparation and harmonization

Data preparation and harmonisation processes are required before analysis and spatialisation, to ensure that datasets can be used consistently across modules. Data harmonisation and standardisation involve aligning spatial datasets in terms of coordinate reference systems, spatial resolution, and attribute structure. This may include reprojecting layers to a common coordinate system, resampling data to a compatible spatial resolution, and standardising attribute fields, units, or classification schemes across datasets. These steps are necessary to enable the integration of multiple data sources, support comparability between indicators, and ensure that subsequent analyses are technically consistent and interpretable.

Traceability and replicability documentation

All data processing and analytical steps should be documented in terms of data used, methods applied, the rationale for key decisions, and any known limitations. This supports transparency, enables reuse of results in planning and decision-making processes, and facilitates monitoring approaches or future updates of the methodology to enable adaptive planning approaches.

- **Data-oriented** documentation includes providing detailed metadata for all datasets, covering source, date, resolution, units, coordinate reference system, and any relevant contextual information. Quality control checks should be performed to assess completeness, consistency, and reliability. Differences between datasets (units, classification schemes, spatial resolution, scale) should be clearly recorded. Metadata ensures that datasets can be correctly interpreted, reused, and integrated in subsequent analyses.
- **Methodology-oriented** documentation covers all assumptions, thresholds, criteria, and decisions made during data processing. It also includes planning-related key decisions, considerations or constraints that influenced analytical choices or outputs.
- **Limitations-oriented** documentation ensures that known data gaps, uncertainties, or constraints are identified and recorded. This may include low spatial resolution, incomplete datasets, uncertainties in expert judgments, methodological simplifications, or context-specific constraints that affect the interpretation or applicability of results.

Stakeholder engagement processes

Stakeholder engagement is a critical part of the ESPON GILL Methodology, ensuring that results are relevant. feasible, and grounded in local knowledge. Engagement should be iterative, inclusive, and transparent, involving municipal authorities, technical departments, experts, and external stakeholders such as community groups, organizations, or associations. Stakeholders contribute to validating data, refining results, and providing knowledge. This approach ensures that stakeholder input is systematically incorporated.

- **Types of stakeholders:** Engagement should include internal stakeholders (e.g., municipal departments, planners, technical staff, decision-makers) as well as external stakeholders (e.g., citizens, community groups, NGOs, professional associations, other local actors). It also could include relevant supra-municipal authorities to enable vertical coordination. Including a diverse mix ensures that both institutional knowledge and local perspectives are captured.
- **Levels of engagement:** Different approaches should be applied depending on the objective and the expected type of results. Co-creation is used to jointly define actions and priorities, consultation is used to gather feedback on outputs, and validation can be used to confirm the results. Not all stakeholders need to be involved in every module; rather, they should be engaged at the appropriate stage with the results that are relevant to them.
- **Iterative engagement:** Engagement should be continuous throughout the process, allowing stakeholders to review and refine spatial representations, classifications, or proposed interventions. Workshops, targeted consultations, or technical review sessions are recommended to maintain active involvement and improve the interpretability and completeness of results.

5.1.4 General Resources

The general resources constitute the supporting framework developed within ESPON GILL to complement the application of the methodology. They provide municipalities with cross-cutting guidance on key conceptual, institutional, and practical aspects relevant to GI planning and implementation. These resources are not tied to individual modules, but rather support the overall understanding, and effective use of the methodology across different local contexts.

Annex 1.1 ESPON GILL Glossary
Annex 1.2 Enablers and barriers
Annex 1.3 Repository of Good Practice Plans for Urban GI

5.2 MODULE 1: Definition of Local Policy Goals and Baseline Analysis

The aim of Module 1 is **to establish the strategic and analytical foundation for developing the ESPON GILL Methodology in a designated municipality.** It ensures that GI goals are grounded in evidence, i.e., aligned with existing policies, supported by reliable data, and spatially framed within meaningful and operational study areas. Combining policy review, data consolidation and spatial scoping process, this module builds a comprehensive baseline that informs the subsequent phases of the ESPON GILL Methodology.

The module supports municipalities in:

- Understanding their current GI-related policy landscape, challenges, and ESS priorities.
- Consolidating relevant data for GI assessment in a structured and accessible way.
- Defining and validating the spatial extent and analytical scales for the GI analysis, using GIS-based methods.

The **actions in Module 1** that create the necessary context for further development of the ESPON GILL Methodology are:

- **Action 1.1. Analysis of local baseline for the definition of GI goals:** This action focuses on reviewing existing plans, strategies, and diagnosis documents to identify the current GI-related objectives of the municipality, as well as their challenges, and ESS needs. The action looks at cross-sectoral coherence across different local plans and strategies, and future trends, to support the formulation or refinement of context-specific GI goals.
- **Action 1.2. Gathering and storage of data:** This action establishes a centralised and accessible repository for all GI-relevant data collected from European, national, regional, and/or local sources. It supports the systematic compilation, quality checking, and documentation of data with metadata, creating a reference set for future spatial analysis, assessment, as well as for running the activities in the subsequent modules.
- **Action 1.3. Definition of scope and delimitation of the study area:** This action defines the spatial boundaries and analytical scale for the assessment.

5.2.1 Action 1.1. Analysis of local baseline for the definition of GI goals

The objective of Action 1.1 is to define GI goals associated with local baseline analysis, context-specific challenges, and ESS.

Data input

- **Spatial plans and strategies:** urban plans, development plans, regional plans, etc.
- **GI-related strategies and plans:** GI plans, tree plans, biodiversity plans, greenspace management plans, urban nature plans, etc.
- **Non-GI strategies and plans:** mobility plans, amenity plans, public space plans, etc.
- **Existing city diagnosis and future trends related to GI:** climate change, landscape, natural resources and biodiversity, etc.

Key activities

1. **Collect and review relevant documents:** Collection of municipal spatial plans, GI-related strategies, sectoral policies, and existing diagnosis studies that can contribute to GI development. Review of future development trends (such as demographic shifts or climate projections) to understand external drivers that may shape GI needs in the (near) future.

2 **Extract and analyse GI-related content:** the collected documents are examined to identify current objectives, targets, and goals related to GI, as well as existing or emerging challenges that may constrain or support GI implementation. This analysis helps determine the current level of ambition and highlights already collected challenges and GI related goals.

3 **Conduct a cross-sectoral and multilevel analysis:** this analysis compares goals across different planning levels and sectors to identify (in)consistencies, complementarities, and tensions. It highlights synergies that can enhance GI integration and exposes potential conflicts or trade-offs that may require strategic attention, e.g., between urban development priorities and green space preservation.

4 **Align the GI ambition with environmental and planning standards:** existing goals and approaches are assessed in relation to the established GI, biodiversity, climate adaptation, and environmental standards at European and national levels. This ensures that the municipalities' GI ambitions are aligned with broader regulatory frameworks and sustainability commitments.

5 **Identify and prioritise relevant challenges related to GI:** the activity focuses specifically on identifying the main environmental, social, technical, and governance challenges that may affect GI. Challenges are then prioritised based on their urgency, impact, and relevance to municipal planning, helping ensure that the goal setting is grounded in real constraints and needs.

6 **Identify and prioritise relevant ESS:** this activity determines which ESS are currently included in existing plans and strategies, and which are missing or underrepresented. Screening the ESS which are most relevant to local needs (such as flood regulation, cooling, recreation, or biodiversity) contributes to setting more targeted and functional GI goals.

7 **Formulate or refine local GI goals:** Based on the gaps, synergies, challenges, and ESS priorities identified, this activity centres on defining or updating the municipalities' GI goals in relation to the local baseline conditions and strategic needs. Whenever possible, the GI goals should be specific and measurable.

Selection of methods that could be used

- **Document review:** systematically analyse existing plans, strategies, and other relevant documents to extract GI-relevant information.
- **Policy and strategy mapping:** organise and visualise the relationship, hierarchies, and interactions between different policies to understand coherence, gaps, and cross-sectoral linkages.
- **Stakeholder consultation:** engage relevant stakeholders – within the municipality (e.g., other departments or agencies, decision-makers and politicians) and/or external actors (e.g., citizens, organisations, associations) – to validate findings and gather additional insights.
- **Expert validation workshop:** review preliminary results with experts to refine and confirm the proposed GI goals.
- **ESS identification:** apply recognised ESS classification (Millennium Ecosystem Assessment - MAES, CICES, IPBES framework) to systematically identify relevant ESS and assess their alignment with municipal priorities.
- **Cross-sectoral coherence analysis:** compare goals and strategies across different sectors and governance levels to identify synergies, redundancies, or conflicts related to GI.
- **Trends and scenarios review:** examine demographic, environmental, land-use, and climate projections to anticipate future pressures and integrate them as GI goals.

Expected results

- **Better understanding of the current plans and strategies related to GI (or potentially impacting it):** a consolidated overview of all municipal, regional, and sectoral plans and strategies that influence GI.
- **Final set of GI goals:** a consolidated set of GI goals, updating those extracted from existing documents with the ones based on identified challenges, ESS priorities, synergies, and planning coherence.

- **Screening of challenges and ESS derived from identified GI goals:** an initial assessment of the main GI-related challenges and the ecosystem services prioritised.

Checklist

- ☑ Relevant plans and strategies have been collected and reviewed.
- ☑ Existing GI-related goals, targets, and objectives have been identified or developed.
- ☑ Key GI-related challenges have been identified and prioritised.
- ☑ Relevant ESS have been screened.
- ☑ Resulting GI goals, challenges and ESS have been validated with relevant internal and/or external stakeholders.
- ☑ The final consolidated set of GI goals has been produced and documented, integrating existing, reformulated, and new goals derived from the baseline analysis.
- ☑ **Nature Master**: Synergies and trade-offs across sectors and planning levels have been assessed

Recommendations from practical implementation

- Develop a stakeholder map or analysis to understand which stakeholders should be involved at which modules to gather relevant information and validate specific information
- Define different ways of validating or gathering goals according to the type of stakeholder, to ensure feasibility and local relevance.
- Anticipate future pressures by reviewing demographic, environmental, land-use and climate trends, and integrate them as GI goals.

Additional resources

Annex 2.1 - Overview of EU policies and legislation with a territorial dimension, or relevant for urban green transition

5.2.2 Action 1.2. Gathering and storage of data

The objective of Action 1.2 is to develop and implement a centralised and accessible GI data repository, consolidating verified data from multiple sources.

Data input

- **Data collected** in Action 1.1
- **Spatial, environmental and socio-demographic data** from municipal, regional and/or national geoportals and/or statistical services
- **Data from EU data services**, in case local data is not available (e.g., Copernicus, EEA, GISCO, EUROSTAT)

Key activities

1. **Collect and consolidate GI-related data:** systematically gather relevant GI data, as well as any additional data related to the challenges and ESS identified in the Action 1.1, all from verified sources. The overall data inventory will serve as the foundation for the subsequent analysis.
2. **Organise and structure data in a centralised repository:** for easy retrieval, store the collected data in an accessible and centralised repository.

3 **Include document metadata and ensure data quality:** include detailed metadata, perform a quality control, and document the procedures implemented, to guarantee traceability, reliability, and future usability.

4 **Create a basis for subsequent analysis and planning:** maintain and update the repository as a core element for future actions of the ESPON GILL Methodology (GI analysis and definition, GI demand analysis, etc.)

Selection of methods that could be used

- **Desk-based data review:** systematically identify, collect, and verify relevant data from European, national, regional, and local sources.
- **Data structuring and database design:** organise the collected data in a centralised repository using consistent formats, metadata, and quality control standards.
- **Stakeholder and interdepartmental consultation:** engage relevant departments and experts to validate data completeness, address gaps, and ensure usability.

Expected results

- **Centralised GI data repository:** a structured repository compiling verified data from European, national, regional, and/or local sources.

Checklist

- ☑ GI-related data has been collected and consolidated from verified sources, including data on challenges and ESS.
- ☑ Data repository formats accommodate diverse types (spatial, statistical, quantitative, and qualitative) for flexible analysis.
- ☑ Data has been organised and stored in a centralised repository.
- ☑ Metadata has been produced to contextualise the data.
- ☑ **Nature Master**: Quality control procedures are documented to ensure traceability, reliability, and future usability.

Recommendations from practical implementation

- Ensure the repository can accommodate different data formats, including spatial, statistical, quantitative, and qualitative information.
- Establish a clear update and maintenance plan to keep the repository updated and reliable.
- Leverage existing data systems, visualisation tools, and storage platforms (e.g., municipal data platforms or dashboards) to efficiently access, manage, and share relevant information.
- Define access rights and user roles to facilitate collaboration while protecting sensitive data.
- Ensure interoperability and compliance to data standards for unified integration with other systems.
- Train and guide the team to use the repository effectively.

Additional resources

Annex 2.2 - List of available European data sources
Annex 2.3 - List of data requirements for the ESPON GILL Methodology development

5.2.3 Action 1.3. Definition of scope and delimitation of the study area

The objective of Action 1.3 is to delineate the study area according to the preferred scale of analysis.

Data input

- **Administrative boundaries:** municipal administrative limits, urban core, districts, neighbourhoods, and other officially defined territorial units.
- **Environmental and ecological datasets:** habitat units, landscape units, protected areas, ecological corridors, water bodies.
- **Information on functional area:** mobility zones, urban structure zones, planning sectors, service catchment areas.
- **Land-use and land-cover data:** urban fabric, green areas, agricultural land, natural zones, infrastructure footprints.

Key activities

1. **Define study areas at landscape and urban level:** establish both landscape and urban level study areas, using administrative boundaries as the primary reference, also considering, if needed, environmental or functional information (e.g. LAU or Functional Urban Areas, as defined by Eurostat) to validate or adjust these boundaries. The landscape level analysis considers the surrounding natural and semi-natural areas, beyond the urban core (e.g., agricultural land, forests and meadows). In contrast, the urban level covers the built-up areas containing GI.
2. **Specify analytical scales and differentiate urban/landscape contexts:** determine the appropriate analytical scale for each case, reflecting differences in space and ESS capacity. Clearly separate urban cores, neighbourhoods, and functional areas from broader landscape zones to enable tailored GI analysis and ESS assessment. The purpose of defining these two levels of analysis is to account for differences in ESS between natural or semi-natural environments and urban areas, which vary substantially in both extent and quality, requiring different assessment approaches and analytical methods.
3. **Ensure spatial coherence, promote stakeholder validation, and generate GIS output:** verify that the delineated study areas are spatially coherent and aligned with administrative authority, legal competence, and capacity to implement actions. Engage stakeholders to validate the boundaries and incorporate local knowledge. Produce the georeferenced GIS datasets from the selected study areas to support subsequent GI assessment and planning.

Selection of methods that could be used

- **GIS-based spatial analysis:** use GIS tools to map and analyse relevant spatial data to support the delineation of the study area.

Expected results

- **Defined scale of analysis:** clear decision on the level the assessment will be done at landscape level, urban level, or both.
- **Georeferenced study area:** a validated, spatially coherent study area in GIS format, based on administrative boundaries and if needed, adjusted with information on environmental or functional areas.

Checklist

- ☑ Landscape and/or urban level study areas have been defined using administrative boundaries as the primary reference.
- ☑ The scale of analysis (landscape, urban, or both) has been clearly defined and justified.

- ☑ Boundaries have been reviewed and confirmed by relevant stakeholders and municipal departments.
- ☑ The final study area has been produced in GIS to be used in subsequent GI assessment and planning.
- ☑ **Nature Master:** Environmental or functional information has been reviewed and used to validate or adjust the initial boundaries.

Recommendations from practical implementation

- Ensure that the delineation aligns with the municipality's legal authority and competences within its defined boundaries.

5.3 MODULE 2: Definition of the GI Demand

The aim of Module 2 is **to operationalise the conceptual understanding of municipal challenges and GI goals by defining and spatially characterising GI demand**. It translates the identified challenges into areas where there is a need to mitigate, regulate, or improve environmental and social conditions related to GI. Through a combination of challenge prioritisation, data review, spatial analysis, and characterisation of the demand, this module ensures that GI demand is rigorously defined, spatially explicit, and aligned with municipal objectives and standards.

The module supports municipalities in:

- Identifying which challenges can be addressed from a spatial perspective
- Prioritising challenges according to strategic relevance, data availability, and spatial impact.
- Translating challenges into spatially explicit GI demand areas.
- Producing characterised demand maps.

The Module 2 actions that define spatially GI demand are:

- **Action 2.1. Definition and prioritisation of challenges for the GI demand:** identify municipal challenges that GI can address, assessing their spatial relevance, feasibility, and strategic importance to produce a curated and prioritised set of challenges for spatial mapping.
- **Action 2.2. Mapping of the GI demand:** translate the prioritised challenges into spatially explicit GI demand areas. Select suitable datasets and approaches, address data gaps, map challenge distributions, interpret spatial patterns, and generate maps that highlight and characterise GI demand areas.

5.3.1 Action 2.1. Definition and prioritisation of challenges for the GI Demand

The objective of Action 2.1 is to identify and prioritise municipal challenges that can be effectively addressed due to existing information, considering their spatial relevance, severity, and alignment with local GI goals.

Data input

- **Screening of challenges (Action 1.1):** climate-related hazards (e.g., heat stress, flooding), biodiversity loss, lack of accessible green spaces, soil sealing hotspots, etc.
- **Final set of GI goals (Action 1.1):** goals related to climate change adaptation and mitigation, ecological connectivity, public space quality, stormwater management, biodiversity enhancement, urban cooling, etc.
- **Centralised GI data repository (Action 1.2):** spatial layers on land-use/land-cover, green/blue infrastructure assets, environmental indicators, ecosystem service datasets, etc.
- **Georeferenced study area (Action 1.3):** landscape and/or urban study area.

Key activities

1. **Identify challenges relevant to GI and their spatial relevance**: use the screened challenges and established GI goals to determine which municipal challenges can be addressed or improved through GI. Assess their spatial relevance by identifying where these challenges occur, how intense they are, and whether they can be influenced by GI interventions.
2. **Assess feasibility and relevance of potential GI demand**: evaluate which GI-demand can be realistically assessed, based on their alignment with GI goals, their spatial condition within the study area, and the availability and quality of data to support spatial analysis.
3. **Prioritise challenges for GI demand definition**: select the challenges that are strategic, and data supported (existing, or feasible-to-be-developed data). Some criteria could be severity, spatial extent, urgency, vulnerability, population affected, and alignment with municipal priorities. Produce a list of priority challenges for GI demand.

Selection of methods that could be used

- **Desk-based data review:** Check on available datasets, documents, and spatial information to identify and assess relevant inputs for the analysis.
- **Spatial and non-spatial analysis:** Use analytical techniques (GIS-based or descriptive/statistical analysis) to understand distribution patterns, relationships, and relevance of the elements being assessed.

Expected results:

- **Curated list of datasets and applicable assessment approaches:** identified data sources, indicators, and approaches suitable for defining GI-relevant challenges.
- **Revised and prioritised set of challenges:** a list of challenges refined according to spatial relevance, feasibility, and analytical approaches, serving as the basis for defining GI demand.

Checklist:

☑ Priority challenges have been identified and screened.
☑ Challenges have been assessed for spatial relevance and alignment with GI goals.
☑ Challenges have been prioritised using quantitative and/or qualitative approaches.
☑ A structured and prioritised list of challenges has been produced.
☑ **Nature Master**: Feasibility and data availability for assessing GI demands have been evaluated.

Recommendations from practical implementation:

- Consider spatial relevance and scale differences between landscape and urban areas while selecting challenges.
- Consider emerging or future pressures (e.g., climate change, demographic shifts) that may influence the relevance or intensity of challenges over time.
- Document potential gaps, limitations, or uncertainties in the data used for challenge identification, and note how these may affect prioritisation.

Additional resources:

Annex 2.4 - Trigger questions for challenges identification
Annex 2.5 - List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand

5.3.2 Action 2.2. Mapping of the GI demand

The objective of Action 2.2 is to assess the spatial distribution of GI demand across the municipality

Data input

- **Screening of challenges (Action 1.1):** climate-related hazards (e.g., heat stress, flooding), biodiversity loss, lack of accessible green spaces, soil sealing hotspots, etc.
- **Final set of GI goals (Action 1.1):** goals related to climate change adaptation and mitigation, ecological connectivity, public space quality, stormwater management, biodiversity enhancement, urban cooling, etc.
- **Centralised GI data repository (Action 1.2):** spatial layers on land-use/land-cover, green/blue infrastructure assets, environmental indicators, ecosystem service datasets, etc.
- **Georeferenced study area (Action 1.3):** landscape and/or urban study area.

Key activities

1. **Select approaches and datasets for spatial challenge mapping:** select the most appropriate approach and existing datasets for each priority challenge, ensuring they meaningfully represent where GI can respond to that challenge and align with Module 1 goals, targets, and standards.
2. **Address data gaps through targeted collection and spatial analysis:** identify missing or deficient data and complement them using field surveys, stakeholder insights, or expert contributions, ensuring alignment with municipal standards. Where possible, apply spatial analysis techniques (GIS-derived indicators, remote sensing, modelling) to strengthen challenge representation and to support the GI demand identification.
3. **Map the spatial distribution of challenges:** process relevant datasets to create spatial layers showing their placement, magnitude or intensity. These maps constitute the foundational spatial baseline and enable the shift from conceptual challenges to spatialised GI needs. This spatialisation may rely on:
    a. ESS demand maps: cooling demand, flood mitigation demand, air quality regulation demand, recreation needs.
    b. Other thematic spatial layers: representing biophysical or socio-environmental conditions, such as heat exposure, flood-prone areas, pollution hotspots, urban quality indicators, access to GI deficits, imperviousness, noise exposure, soil sealing.
4. **Interpret challenge maps:** interpret each challenge map to determine where the GI demand is placed by analysing the spatial patterns, intensity, and characteristics of the challenge (e.g., defining hot or cold spots).
    a. In some cases, GI demand may coincide with the challenge footprint (e.g., areas with high heat exposure, high pollution, low urban quality, or poor access to green space).
    b. Others GI demand may require complementary or adjacent areas to be included (e.g., upstream zones contributing to flood risk, landscape gaps affecting ecological connectivity).
5. **Generate spatial GI demand maps:** based on the interpretation above, convert the challenge-specific areas into spatial GI demand representations by:
    a. Delineating zones where the challenge reaches high or critical values, following existing standards, thresholds, classifications, or locally defined criteria.
    b. Differentiating levels of GI demand using threshold-based classification, index values, statistical ranges or expert judgement, stakeholder-informed categorisation.

Selection of methods that could be used

- **Desk-based data review:** analyse existing datasets and spatial information to identify relevant inputs for mapping.
- **Spatial analysis:** use GIS and related tools to process, visualise, and integrate spatial data.
- **Thresholding and classification:** apply general criteria or locally defined standards to characterise areas.
- **Validation:** check spatial outputs against local knowledge to ensure maps are interpretable.

Expected results

- **Spatially explicit GI demand maps:** Maps showing GI demand for each prioritised challenge, delineating zones high or critical demand values.

Checklist

☑ Priority challenges have been selected, reviewed, and mapped.
☑ Approaches and datasets are feasible and properly selected for each challenge.
☑ GI demand results are aligned with Module 1 goals.

- ☑ **Nature Master**: Data gaps related to GI demand maps have been addressed through targeted collection (such as expert knowledge) or spatial analysis and modelling.
- ☑ **Nature Master**: GI demand has been interpreted through different criteria, such as thresholds and/or standards.
- ☑ **Nature Master**: Final spatial GI demand maps have been produced, with delineated areas.
- ☑ **Nature Master**: Levels of demand has been characterised.

Recommendations from practical implementation

- Consider whether the spatial resolution of available data allows meaningful assessment of challenges at the intended urban or landscape scales.
- Document of the criteria, thresholds, and methods used.
- Ensure coherence with the analytical scale (landscape or urban) and the type of challenge being assessed.
- Use local knowledge and experience to address existing GI demand (e.g. historic flooded areas, damaged areas and infrastructure due to wind, ...)
- Maintain flexibility to adapt thresholds or classification criteria based on local context or new data.
- Document assumptions and methodological choices to support transparency and replicability.
- Incorporate additional modelling or spatial analysis when necessary (e.g., runoff modelling for flood regulation, cooling potential, connectivity modelling).
- Consider differences between challenge and GI demand depending on scale and ecosystem service. GI demand may occur in areas different from the observed challenge (e.g., upstream areas for flood regulation, or multiple locations to improve access to green space). This distinction should be noted during prioritisation and reflected in spatial interpretation where possible.

Additional resources

Annex 2.2 - List of available European data sources
Annex 2.5 - List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand

5.4 MODULE 3: Definition of the GI provision

The aim of Module 3 **is to operationalise the spatial understanding of existing GI by mapping GI assets and quantifying their associated ESS provision**. It provides a comprehensive and spatially explicit assessment of GI types, subtypes, and the intensity and distribution of the delivered ESS. This module ensures that the GI provision is characterised in a consistent and transparent way, supporting subsequent analysis of provision-demand relation.

The module supports municipalities in:

- Developing a spatially explicit inventory of GI areas across urban and landscape scales.
- Classifying GI into standardised types and/or subtypes to ensure consistency and comparability.
- Identifying and prioritising ESS linked to GI demand.
- Mapping the spatial distribution and intensity of ESS provided by existing GI.
- Producing robust, interpretable, and validated GI provision maps.

The Module 3 actions that define and spatially characterise GI provision are:

1. **Action 3.1. Development of a GI map:** compile available GI-related datasets, identify GI areas, and classify them according to standardised GI types and/or subtypes. Integrate these into a coherent spatial layer.
2. **Action 3.2. Selection of ESS for analysis, based on the GI demand:** identify and prioritise the most relevant ESS to the selected GI demand. Evaluate data availability, methodological feasibility, and alignment with municipal priorities.
3. **Action 3.3. ESS spatial analysis to define the current GI provision:** quantify and map the spatial distribution and intensity of the ESS provided by the existing GI. Interpret and classify the provision levels to produce spatially explicit ESS provision maps to better understand the GI provision.

5.4.1 Action 3.1. Development of a GI map

The objective of Action 3.1 is to create a spatially explicit inventory of existing GI areas, classified according to GI types and subtypes.

Data input

- **GI-related spatial data (Action 1.2.):** tree census, public green spaces and parks, habitat maps, agricultural land, land-cover, biodiversity maps, etc.
- **Guide for GI classification:** existing typologies or standards for classifying GI types and subtypes.
- **Supplementary open datasets:** Alternative GIS sources (such OpenStreetMap or CORINE), satellite imagery or aerial photography (Copernicus or Google Earth Engine) for mapping vegetation and green area.
- **Stakeholder and expert input:** local knowledge to validate GI existence, type, and extent.

Key activities

1. **Prepare GI-related spatial data:** compile available spatial datasets that represent potential GI, including, e.g., tree distribution, public parks, habitat maps, agricultural areas, and other relevant vegetated or natural spaces. Align coordinate systems, formats, and attributes to allow their integration into a single map.
2. **Select and classify GI areas:** identify areas that qualify as GI. Classify them in GI types (e.g., semi-natural greenspaces), and subtypes (e.g. forests, shrubland, rocks...).
3. **Integrate datasets into a single GI map:** combine the classified GI areas into a single map. Resolve spatial overlaps or inconsistencies and ensure each area is correctly attributed, clearly delineated and easily interpretable according to its GI classification.

4 **Validate and refine the GI map:** conduct visual inspection and, if possible, consult local experts to verify its accuracy and completeness. Ensure the GI map captures all relevant green areas and aligns with the scale of interest.

Selection of methods that could be used

- **Desk-based data review:** Analyse datasets to identify relevant inputs for mapping.
- **GIS-based spatial analysis and classification:** Process spatial datasets (land-cover, land-use, OpenStreetMap) according to selected classification.
- **Remote sensing analysis:** Use satellite imagery or aerial photography to complete missing data.
- **In situ field verification:** Conduct on-site checks to validate results.
- **GI Frameworks:** Apply established classification systems to standardise information.

Expected results

- **GI map:** a map where GI areas are identified and classified according to GI types/subtypes at each level (urban/landscape).

Checklist

- ☑ An official GI classification approach has been selected.
- ☑ GI areas have been selected and classified according to a standardised classification.
- ☑ Datasets have been integrated into a single GI map.
- ☑ **Nature Master:** accuracy has been validated through field verification.
- ☑ **Nature Master:** GI areas have been subdivided into standardised subtypes.

Recommendations from practical implementation

- Consider maximum resolution information to keep it useful for planning purposes.
- Before developing the GIS map, the spatial extent of the demand should be clearly defined. This ensures consistency and alignment when combining datasets from different sources or spatial units.
- GI data can be represented in different data layers depending on data types (e.g. point layer for tree census and polygon layer of green spaces).
- Use open-source datasets (e.g., OSM and Copernicus) if municipal data are too scattered or unavailable.
- Categorisation may vary depending on the challenge being addressed, considering which types of GI and ES are best suited to meet specific GI demands. For example, a public forest that is managed as part of the municipality's parks may be categorised as a park if addressing recreational demand, but as a forest if addressing heat stress.
- GI classification should be limited to types of GI (e.g. forest or agricultural land) and avoid categorising data according to planning requirements or protection levels as a GI type (e.g. protected forest or high-productive agricultural land).
- The GI inventory is a key input for ESS modelling (for instance as land-use raster for ESS modelling using InVEST), however, it might require non-GI land-use data (extracted from Copernicus Land Monitoring Service, for example) to produce a complete land-use map.

Additional resources

Annex 2.2 - List of available European data sources
Annex 2.6 – ESPON GILL GI types

5.4.2 Action 3.2. Selection of ESS for analysis, based on the GI demand

The objective of Action 3.2 is to identify priority ESS linked to the GI demand

Data input

- **Centralised GI data repository (Action 1.2.):** ESS-related spatial layers, environmental indicators, biophysical datasets, socio-environmental data.
- **GI map (Action 3.1.):** spatially explicit GI areas classified by types/subtypes.
- **ESS linked to policy goals (Action 1.1.):** cooling, flood mitigation, air quality regulation, recreation/access to green spaces, biodiversity support, etc.

Key activities

1. **Identify ESS relevant to GI demand and policy goals:** use the ESS linked to municipal policy goals (Action 1.1) and the priority GI demand (Action 2.2) to define which ESS are the most relevant for assessing the GI provision.
2. **Assess feasibility and relevance for the ESS analysis:** evaluate which ESS can be meaningfully analysed based on their relation to the GI types and the availability, resolution, and quality of ESS-related datasets included in the repository.
3. **Prioritise ESS for the analysis of the GI provision:** select the most relevant ESS for addressing the identified GI demand, considering data availability and feasibility of methods. Use relevant criteria, such as relevance to GI demand, data availability, methodological feasibility, and alignment with municipal priorities.

Selection of methods that could be used

- **Desk-based data review:** Examine available datasets, documents, and spatial information to identify and assess relevant inputs.
- **Spatial and non-spatial analysis:** Use analytical techniques (GIS-based or descriptive/statistical) to understand distribution patterns, relations, and relevance of the assessed elements.

Expected results

- **Curated list of ESS data sources and methods:** A consolidated overview of available datasets, indicators, and assessment approaches suitable for characterising GI through ESS.
- **Revised and prioritised set of ESS:** A refined selection of ESS aligned with the GI demand, supported by feasible data and proper methods.

Checklist

- ☑ ESS linked to policy goals have been identified and reviewed.
- ☑ GI demand maps have been consulted to ensure relevance of the selected ESS.
- ☑ Available data sources and indicators for each ESS have been assessed.
- ☑ A prioritised and realistic set of ESS have been defined and validated.
- ☑ **Nature Master:** Feasibility and suitability of existing methods for each ESS have been evaluated.

Recommendations from practical implementation

- Consider an iterative process to allow refinement of the ESS selection as new requirements emerge (new dataset or municipal priorities).
- Ensure ESS categories are distinct so to avoid overlaps across the selected services.
- Document all assumptions, selection criteria, and rationale to ensure transparency and replicability.
- Avoid selecting ESS based only on policy expectations, since data or methodological feasibility may be deficient.

5.4.3 Action 3.3. ESS Spatial analysis to define the current GI provision

The objective of Action 3.3 is to assess the spatial distribution of the ESS

Data input

- **GI map (Action 3.1):** GI map classified in types/subtypes.
- **Centralised data repository (Action 1.2):** relevant spatial datasets, including land-use, habitat maps, urban green space layers, and environmental indicators.
- **ESS models and frameworks:** Existing ESS models, spatial indicators, or methodologies linking GI to ESS provision.

Key activities

1. **Select proper approaches and datasets for ESS spatial provision:** identify the most appropriate approach and datasets to represent the spatial distribution and intensity of each previously selected ESS. This involves determining how the existing GI can be translated into ESS provision using suitable indicators, metrics, or qualitative descriptors. Approaches should reflect the biophysical characteristics of each ESS and ensure results can be interpreted through reclassifications or thresholds.
2. **Address data:** Once the required datasets are defined, data gaps are identified and addressed by generating derived spatial indicators or complementing available information with remote sensing, basic modelling, or expert input.
3. **Map the ESS provision:** All relevant datasets are processed to create spatial layers that represent ESS provision across the municipality. This indicates how strong each part of the GI contributes to the selected ESS and in some cases, the surrounding influence zones. It may include spatial representation of cooling provision, flood regulation potential, air quality regulation potential, habitat provision, recreation, etc.
4. **Interpret the ESS provision maps:** The spatial outputs are analysed to understand the distribution, intensity, and spatial patterns of ESS provision. This allows to identify levels of provision, differences between GI types, and spatial relations where GI influences surrounding areas. The interpretation accounts for ecological processes, landscape structure, and local conditions to provide a coherent understanding of the current GI provision.
5. **Translate the ESS provision into GI provision:** match mapped ESS levels to the corresponding GI areas to identify how much of each ES is provided by each GI element. This transforms the ESS information into a structured and comparable GI provision map. Provision levels are delineated using thresholds, index ranges, or locally validated criteria.

Selection of methods that could be used

- **Desk-based data review:** Analyse existing GI maps and associated datasets to identify relevant inputs for each ESS.
- **Spatial analysis and modelling:** Apply GIS tools or ESS spatial models, to spatialise ESS provision.
- **Processing and interpretation:** Use spatial processing tools to quantify, classify, or visualise ESS provision across the mapped GI areas.

Expected results

- **ESS provision maps:** Representing the intensity and distribution of each ESS delivered.
- **GI provision maps:** GI areas classified according to their capacity to deliver ESS, reflecting the intensity and distribution of ESS provision across the municipality.

Checklist

- ☑ The selected approaches for spatialising ESS provision are appropriate for each ESS type.
- ☑ All relevant GI and ESS-related datasets have been collected and prepared for analysis.
- ☑ ESS provision is linked to the mapped GI areas and classified consistently across types and/or subtypes.
- ☑ **Nature Master:** Quantitative assessment methods have been applied to spatialise ESS provision where necessary.
- ☑ **Nature Master:** Data processing and spatial modelling outputs have been verified for consistency and accuracy.

Recommendations from practical implementation

- Ensure that the resolution selected for the ESS analysis provides relevant information for your municipality.
- Ensure maximum spatial resolution possible.
- Use consistent classification logic across ESS to support comparability.
- When using InVEST to map ESS provision, base the model on a land-use map derived from the GI inventory, supplemented with additional land-use data if needed, to enable spatial assessment of multiple ESS simultaneously.

Additional resources

Annex 2.2 - List of available European data sources
Annex 2.5 - List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand
Annex 2.7 - ESS evaluation factsheets

5.5 MODULE 4: Unmet demand evaluation

The aim of Module 4 is **to operationalise the comparison between GI demand and GI provision to identify spatial mismatches where GI demand is not fully addressed by existing GI.** It provides a spatially explicit assessment of unmet demand, differentiating areas where GI entirely lacks from areas where GI does exist, but the related ESS provision is undersupplied. This module ensures that gaps in GI delivery are characterised and considered for planning and decision-making.

The module supports municipalities in:

- Identifying areas where GI demand is not met by GI provision.
- Differentiating areas lacking GI, from areas where GI exists, but ESS provision is undersupplied.
- Producing maps and characterisation of unmet GI demand to support prioritisation of interventions.

The action of Module 4 that define and spatially characterise unmet GI demand is:

1. **Action 4.1. Spatial analysis of GI unmet demand:** Identify unmet GI demand where GI demand is not met by existing GI provision, either due to the lack of GI or undersupplied ESS provision.

5.5.1 Action 4.1. Spatial analysis of GI unmet demand

The objective of Action 4.1 is to identify unmet GI demand where GI demand is not met by existing GI provision, either due to the absence of GI or the undersupplied ESS provision.

Data input

- **GI demand maps (Action 2.2):** spatially explicit GI demand map(s).
- **GI provision maps (Action 3.3):** spatially explicit GI provision map(s): GI map and/or ESS maps (maps quantifying the intensity and capacity of ESS).

Key activities

1. **Prepare GI demand and provision datasets:** ensure that spatial layers representing GI demand (from Module 2) and GI provision (from Module 3) are consistent in terms of coordinate systems, resolution, and attribute structure. Units or classification schemes are standardised, and any differences are to be documented to ensure transparency and traceability.
2. **Assess spatial correspondence between GI demand and provision:** two approaches are to be applied, depending on data compatibility:
    a. **Direct ESS-based comparison**: when GI demand and provision are expressed in compatible units, overlay the datasets and calculate the difference for each spatial unit. Areas where provision falls short of demand are identified, forming the preliminary map of unmet GI demand.
    b. **Classification-based comparison**: when units differ or direct comparison is not feasible, use the classification of demand and provision layers (e.g., low, medium, high, or index-based categories). Compare these classes to detect areas where demand exceeds provision, highlighting spatial gaps in relation to GI unmet demand.
3. **Incorporate functional influence areas:** Recognise that some ESS, such as flood regulation, cooling, or ecological connectivity, can affect surrounding areas. Mapping these functional influence areas helps capture the spatial extent over which services reach beneficiaries – upstream, downstream, or in adjacent areas. This step ensures that unmet demand reflects the potential of GI to provide services where they are needed, supporting further assessments (e.g., ESS flow).
4. **Interpret and characterise unmet GI demand**: Compare GI demand and GI provision maps to identify areas where demand is not fully met, generating the following gaps:

a. **Areas with lack of GI:** lack of GI where the demand exits, representing. absence of GI provision, indicating opportunities for the implementation of new GI.

b. **Areas with GI, although with ESS provision undersupplied:** Areas where GI exists, but the related ESS provision does not match the corresponding demand. These areas highlight underperforming GI, where targeted enhancement, improvement or management measures could improve the level of ESS provision.

5 **Generate and document unmet GI demand outputs:** consolidate the results from the previous activities into final products. Represent spatially those areas where GI provision does not meet the identified GI demand and characterise the unmet demand for each ESS. Ensure that both features – with no GI, and with GI not completely supplying ESS provision – are clearly delineated.

Selection of methods that could be used

- **GIS-based spatial analysis:** Perform overlay analysis, subtraction, and other geoprocessing procedures.

Expected results

- **Unmet GI demand map:** a spatially explicit map highlighting areas where GI provision does not meet the identified GI demand, reflecting gaps in ESS delivery.
- **Characterisation of unmet GI demand:** a detailed description of unmet GI demand per ESS type (indicating which specific ESS provision are undersupplied in each area), providing the basis for prioritising future GI interventions.

Checklist

- ☑ Spatial correspondence between GI demand and provision has been assessed using direct or classification-based comparison.
- ☑ Areas with no GI have been identified.
- ☑ Unmet GI demand maps have been generated.
- ☑ Methodological assumptions and criteria have been documented.
- ☑ **Nature Master:** Functional influence areas have been incorporated where relevant.
- ☑ **Nature Master:** Areas with undersupplied ESS provision have been identified.
- ☑ **Nature Master:** ESS specific characterisation has been generated.

Recommendations from practical implementation

- Ensure the maximum spatial resolution data are used in both GI demand and provision analysis.
- The development of the unmet demand is highly dependent on the results from Modules 2 and 3; therefore, this output may be omitted in the absence of those prior results.
- Depending on the type of demand, the unmet demand can correspond directly to the assessed demand (as identified in the challenge analysis – action 2.2).
- Using same model can help in defining comparable metrics between the demand, the provision and the unmet demand (e.g. InVEST models).
- InVEST ESS modelling tools often calculate both the provision volume of an ESS and the unmet demand (for instance, in the case of stormwater management, InVEST models both the percolation and retention services, i.e., the met demand and the unmet demand (run-off volume).

Additional resources

Annex 2.5 - List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand
Annex 2.7 - ESS evaluation factsheets

5.6 MODULE 5: GI deployment map

The aim of Module 5 is **to operationalise the identification of areas suitable for GI implementation by combining the opportunity mapping and identified unmet GI demand.** It provides a spatially explicit assessment of potential deployment sites, highlighting locations where GI can be both practically implemented and socially desired, at the same time addressing gaps in ESS provision. This module ensures that the opportunities for GI deployment are characterised and prioritised, considering geographical areas for interventions, as well as their functions and ESS.

The module supports municipalities in:

- Identifying areas where GI deployment is technically feasible and socially supported.
- Integrating unmet GI demand with GI implementation feasibility and stakeholder preferences to determine priority intervention areas.
- Producing prioritised deployment maps with detailed characterisation.

The Module 5 actions that identify and prioritise areas for GI deployment are:

1. **Action 5.1. Opportunity mapping development: identify** and map areas suitable for GI deployment by assessing technical feasibility, (considering physical and contextual constraints), and integrating stakeholders' inputs. Combine these spatial layers to produce a co-created opportunity map which highlights key areas for intervention.
2. **Action 5.2. Prioritisation of GI deployment sites:** intersect the opportunity map with unmet GI demand to identify high-priority GI deployment areas. Rank and characterise sites based on unmet ESS demand, technical feasibility, and stakeholder support, producing a prioritised GI deployment map for planning and decision-making.

5.6.1 Action 5.1. Opportunity mapping development

The objective of Action 5.1 is to assess the spatial feasibility for GI deployment by combining technical constraints with stakeholder preferences.

Data input

- **GI data repository (Action 1.2):** Land-use and land-cover data, parcel or census data (ownership and property boundaries), public space inventories, infrastructure networks (roads, utilities, drainage), legal or zoning restrictions, etc.

Key activities

1. **Identify and map technically feasible areas for GI deployment:** assess physical, spatial, and contextual constraints to determine where GI can potentially be implemented. These factors define the baseline feasibility map indicating where GI implementation is technically possible, considering: (i) availability of open or underused space, (ii) existing proper land-use or land-cover, (iii) land ownership and management type, and (iv) any legal, regulatory, or governance restrictions.
2. **Integrate stakeholder and community preferences:** engage municipal authorities, local experts, and community stakeholders to understand priorities, desired locations, and expectations for new GI. Use participatory tools such as workshops, surveys, or collaborative mapping to spatially represent their preferences. This ensures the opportunity mapping aligns with local needs and enhances acceptance and long-term stewardship.
3. **Combine feasibility conditions with stakeholder preferences:** overlay the technical feasibility assessment and the existing local preferences, identifying areas where conditions for GI deployment are wider. This integrated analysis produces a co-created opportunity map that highlights the priority areas.

It also reveals two valuable targets for future planning or governance considerations within the municipality: the identification of those technical feasible areas with lower interest and those areas in which GI are highly desired by stakeholders but currently constrained.

Selection of methods that could be used

- **GIS-based analysis:** integrated analysis and mapping to combine different criteria into coherent spatial outputs.
- **Spatial decision-support methods:** apply scoring techniques and multi-criteria assessment to integrate diverse criteria in a comparable output.
- **Stakeholder engagement and co-creation approaches:** ensure that municipal authorities, local experts, and community groups collaboratively shape the process and validate its outcomes.
- **Participatory mapping techniques:** capture spatially explicit stakeholder preferences and local insights through interactive mapping exercises, workshops, or the use of digital tools.

Expected results

- **Opportunity map for GI deployment**: a co-created opportunity map identifying priority areas for GI deployment, integrating community and stakeholder preferences for desired locations with technical feasibility.

Checklist

- ☑ Feasibility and preference layers have been successfully overlaid to identify areas where both conditions align.
- ☑ Co-created opportunity areas have been clearly outlined.
- ☑ **Nature Master**: Technical feasibility factors have been fully assessed, considering e.g., available space, land-use/land-cover, ownership, management responsibilities, and/or legal and regulatory constraints.
- ☑ **Nature Master**: Stakeholder and community preferences have been collected, using participatory mechanisms.

Recommendations from practical implementation

- Ensure that feasibility criteria are context-specific and validated by municipal experts.
- Consider governance and legal feasibility alongside physical space availability.
- Ensure that engagement and participatory processes are inclusive and transparent.
- Adopt an iterative process to validate intermediate outputs with relevant actors.

5.6.2 Action 5.2. Prioritisation of GI deployment sites

The objective of Action 5.2 is to identify high-priority GI deployment areas by intersecting opportunity mapping with unmet demand zones.

Data input

- **Opportunity map (Action 5.1):** map highlighting areas where GI deployment is technically feasible and socially desired.

- **Unmet GI demand maps (Action 4.1):** maps showing areas where GI provision does not meet identified demand, including both locations with no GI, and areas with undersupplied ESS provision.

Key activities

1. **Integrate unmet GI demand with opportunity mapping:** combine the spatial outputs of the unmet GI demand assessment (areas with undersupplied ESS provision or absence of GI) with the opportunity map (technically feasible and socially supported areas). This integration highlights zones where the urgency of addressing ESS deficits overlaps with realistic conditions for implementation.
2. **Rank potential GI deployment sites based on combined criteria:** evaluate the identified intersecting areas using a prioritisation criterion that incorporates unmet demand intensity, type of ESS deficit and the opportunity mapping (technical feasibility, stakeholder preference levels, etc.). Ranking may be performed through scoring, weighting, multicriteria assessment, or expert evaluation, depending on available data and municipal needs. The result is a graduation of priority sites for the potential implementation of GI.
3. **Validate prioritised GI deployment areas:** review the prioritised sites with municipal planners, technical experts, and stakeholders. Validation may lead to adjustments in rankings, the inclusion of locally known constraints not previously identified, or the reclassification of sites with strategic relevance for long-term planning. Final outputs reflect both data-driven analysis and informed judgement from local experts.

Selection of methods that could be used

- **GIS-based spatial integration and analysis:** overlay resulting spatial outputs using different spatial processes.
- **Multicriteria or scoring-based prioritisation methods:** apply weighting or ranking systems that combine multiple layers.
- **Expert assessment and participatory review:** incorporate expert judgement and stakeholder validation to reflect a realistic output regarding context-based insights and priorities.

Expected results

- **Prioritised GI deployment map:** a map identifying areas where unmet GI demand overlaps with feasible and socially supported GI opportunities.
- **Characterised priority deployment areas:** a structured description of priority sites, detailing the types of unmet demand, feasibility conditions, and interest that justify their ranking.

Checklist

- ☑ Unmet GI demand and opportunity maps have been prepared for integration.
- ☑ Spatial intersections between unmet demand and opportunity areas have been produced.
- ☑ Prioritisation criteria (ESS deficits, feasibility, stakeholder preferences) have been defined and consistently applied.
- ☑ Ranked GI deployment sites have been produced using scoring, weighting, or expert-based assessment.
- ☑ A final prioritised GI deployment map and supporting documentation have been produced.
- ☑ **Nature Master:** Technical, legal, and governance constraints have been reviewed for defining the top-priority areas.

Recommendations from practical implementation

- Ensure that spatial resolution, classification, and attribute structures of input layers are compatible before integration.

- Consider the relative importance of each ESS unmet demand and recognise areas where the footprint of provision may extend beyond GI boundaries (e.g., upstream flood regulation).

5.7 MODULE 6: Inform planning

The aim of Module 6 is **to operationalise the integration of GI into local planning by providing municipalities** with spatially explicit and context-dependent GI-related interventions (either new GI or GI enhancement and management actions) and operational guidelines that consider local technical feasibility, functional objectives, stakeholder preferences, and planning constraints. It ensures that GI interventions are aligned with planning instruments, implementable, and strategically targeted to effectively deliver ESS.

The module supports municipalities in:

- Translating priority GI deployment areas into implementable, context-specific GI interventions.
- Incorporating technical feasibility, unmet demand, stakeholder input, and planning constraints into type definitions.
- Producing spatially explicit maps and operational guidelines to support integration of GI into urban and landscape planning.

The action of Module 6 that define GI interventions for integration into local planning is:

1 **Definition of GI interventions for integration into local planning:** build context-specific GI interventions by combining priority GI deployment areas with planning considerations. Develop operational guidelines for planners that consolidate spatial allocations, functional objectives, implementation considerations, and links to existing planning regulations and standards.

5.7.1 Action 6.1. Define GI interventions for integration into local planning

The objective of Action 6.1 is to define context-specific GI interventions by building on GI deployment areas, and to develop planning recommendations that integrate these GI types into local planning processes.

Data input

- **Current and ongoing GI-related plans (Action 1.1):** spatial plans (general urban general plans, development plans, etc.), GI-related strategies and plans (GI plans, tree plans, biodiversity plans, etc.), non-GI strategies and sectoral plans (mobility plans, public space plans, etc.).
- **GI map (Action 3.1):** mapped GI areas classified according to defined GI types and subtypes for urban and/or landscape levels.
- **Prioritised GI deployment map (Action 5.2):** map identifying priority areas where unmet GI demand overlaps with GI opportunities.
- **Characterised priority deployment areas (Action 5.2):** structured description of priority sites.

Key activities

1 **Identify suitable GI options for priority areas:** based on the prioritised intervention areas from Module 5, identify the GI options that are best suited to each area by considering spatial conditions, technical feasibility, GI unmet demand, and stakeholder preferences. This activity establishes an initial matching between each site's characteristics and potentially effective GI interventions.

2 **Deploy context-specific GI:** organise the identified GI options into coherent interventions. These interventions not only should be grouped by their primary functions (e.g., stormwater management, cooling, biodiversity support), but also by their physical shape, scale, or expected implementation timeframe. The aim is to select a set of GI interventions that be applied by planners.

3 **Integrate planning barriers and enablers:** review the selected GI interventions in relation to existing planning instruments, zoning regulations, land-use designations, and municipal strategies (Modules 1 and 5). This ensures that each intervention is not only technically appropriate but also feasible within the existing governance and regulatory framework. Barriers such as restrictive zoning or unclear manage-

ment responsibilities, as well as enablers such as supportive policies or available public land, are incorporated into the intervention definition.

4 **Validate GI intervention with planners and designers:** engage municipal planning, urban/environmental design teams, and technical departments to verify that the proposed GI interventions are realistic, implementable, and aligned with current planning priorities. This collaborative review may lead to adjustments in the resulting intervention design, functional objectives, or applicability conditions.

5 **Produce spatial representation of GI interventions**: translate the validated GI interventions into spatially explicit information to reshape the GI map developed in Module 3, showing where each intervention may be deployed. These maps integrate priority areas, planning conditions, feasibility constraints, and functional objectives, providing planners with a practical tool to support coherent and targeted GI deployment.

6 **Validate GI interventions with the local community**: engage local communities to ensure the proposed GI interventions are in line with their actual needs, and if they could be improved. The degree of co-creation can vary depending on the openness of the consultation and on the level of detail of the proposed GI interventions and the spatial allocations.

7 **Produce final GI guidelines for integration into planning instruments:** the final activity consists of preparing a clear and operational set of guidelines that municipal planners can directly embed into planning processes, especially regarding future GI deployment. These guidelines consolidate the GI descriptions, the corresponding spatial allocation maps, and the associated design principles and functional objectives. They also outline key considerations for implementation and long-term maintenance, specifying how each intervention aligns with existing planning regulations, standards and instruments.

Selection of methods that could be used

- **GIS-based spatial analysis**: apply geoprocessing and spatial integration techniques.
- **Classification methods:** develop spatially explicit classifications by organising information into coherent groups based on functional objectives, physical characteristics, and contextual conditions.
- **Planning instrument analysis:** review zoning plans, land-use regulations, municipal strategies, and governance frameworks to identify planning barriers and enablers**.**
- **Guideline development and synthesis:** consolidate information, spatial allocations, functional objectives, and implementation considerations into a clear and operational set of guidelines aligned with planning processes and regulatory instruments.

Expected results

- **GI intervention map:** updated and spatially refined GI layers indicating where each intervention can be applied, supporting consistent and targeted application in planning and implementation.
- **Planning GI guidelines:** a consolidated set of GI intervention descriptions, spatial allocation criteria, functional objectives, and implementation considerations, aligned with existing planning regulations and ready for integration into municipal planning instruments.

Checklist

☑ Relevant planning documents (related or not with GI) have been reviewed, and key barriers and enablers have been identified.
☑ Spatial GI data from Module 3 and prioritised deployment sites from Module 5 have been prepared for intervention definition.
☑ GI options suitable for each priority area have been identified based on spatial characteristics, unmet demand, feasibility, and stakeholder preferences.
☑ Context-specific GI interventions have been developed and clearly defined with functional objectives and applicability conditions.

- ☑ Planning barriers and enablers have been integrated into GI suitability and deployment recommendations.
- ☑ Proposed GI have been validated with municipal planners, experts, and local actors.
- ☑ Spatial representations of GI have been produced and incorporated into an updated GI map.
- ☑ Final GI guidelines have been completed for integration into planning instruments.
- ☑ **Nature Master**: Guidelines have considered principles, implementation considerations, and planning links.

Recommendations from practical implementation

- Ensure the identified GI interventions are consistent with the classification framework developed in Module 3.
- Recognise that planning barriers (e.g., restrictive zoning, fragmented ownership) and enablers (e.g., supportive strategies, available public land) vary across the territory and may require site-specific adjustments to GI typologies.
- Ensure that stakeholder validation reflects the opinion from different municipal departments (urban planning, environment, public works), as well as from relevant local community members.
- Ensure that final GI guidelines are written in an operational, planner-friendly format that facilitates direct integration into urban plans, design standards, or regulatory procedures.

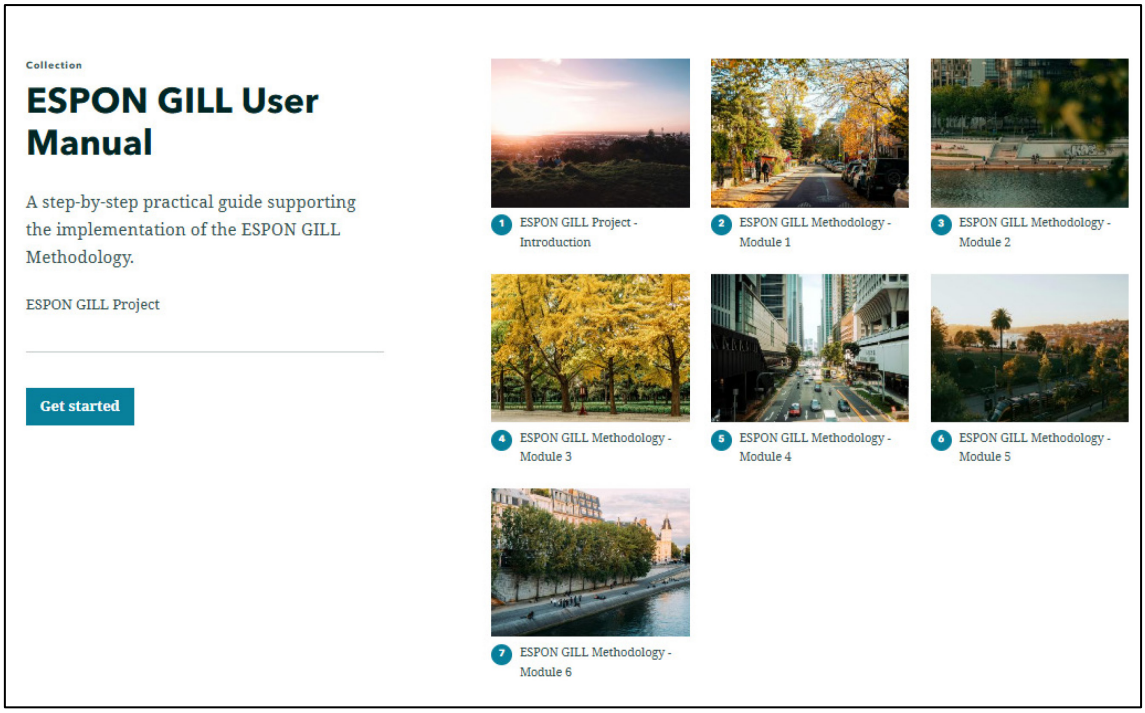
Additional resources

Annex 2.1 - Overview of EU policies and legislation with a territorial dimension, or relevant for urban green transition

5.8 ESPON GILL User Manual

A dedicated User Manual[6] – in the form of a **step-by-step practical guideline** – supports the implementation of the ESPON GILL Methodology by any interested municipality, primarily targeting planners and policy practitioners (urban planners, municipal officials, local planning agencies, environmental managers). The ESPON GILL User Manual was developed within the ESPON Portal to provide target users with an interactive, online resource that is more practical and accessible than a traditional static document. This approach enabled the integration of relevant information, tools, and data into a single and dynamic environment, accessible through a landing page (Figure 5.2).

Figure 5.22
ESPON GILL User Manual landing page



The ESPON GILL User Manual is structured to guide users through the methodology in a systematic way and includes:

- An **introductory section** with general information about the ESPON GILL Methodology, a glossary of key concepts (highlighting GI and ESS), a detailed typology of GI, an overview of the step-by-step approach, and a summary of the case studies.
- A **detailed description of each module** of the ESPON GILL Methodology, including links to standalone files containing all the technical annexes for users who require in-depth methodological guidance or data specifications.

It is complemented by the **Case Study Dashboard**[7] (Figure 5.3) where the main map outputs generated through the implementation of the ESPON GILL Methodology in the six case studies are presented, providing

[6] The ESPON GILL User Manual is publicly available in the ESPON Portal: https://gis-portal.espon.eu/arcgis/apps/storymaps/collections/ee3591c1f3a54944aa5f4335296943f1

[7] The ESPON GILL Case Study Dashboard is publicly available in the ESPON Portal: https://gis-portal.espon.eu/arcgis/apps/storymaps/collections/e0987c677fff423dada48caa8262bc4a

practical examples and visual guidance for local application. Links to the individual case study reports is also included.

Figure 5.33
ESPON GILL Case Studies dashboards

6. Implementation in the Case Studies

The ESPON GILL Methodology was successfully implemented across the six case studies, and the learnings from this iterative process enabled its refinement, including the identification of common emerging enablers and barriers. General findings from the case studies, along with feedback from stakeholders, have provided valuable lessons learnt regarding the utility of the method and its potential future application in practice.

The **implementation of the ESPON GILL Methodology across the six case studies** generated a wide range of valuable outputs. This process was carried out with the support of three SHCs, as well as through several bilateral online and *in-situ* meetings with the case studies. These interactions enabled exchanges with local technical experts at different stages of the process, including the identification of objectives, the selection of ESS to be assessed, the mapping of areas, the presentation of results, and the refinement and improvement of the outputs.

On the one hand, the project **identified a series of GI-related plans and compiled and consolidated existing GI-related data**, **which contributed to a clearer understanding of the local context.** These outputs offer an overview of each municipality's starting point and help identify potential needs related to data or planning gaps. On the other hand, the project enabled access to multiple spatial datasets derived from the application of established methods across the various stages of the proposed methodology.

It is important to highlight that planning systems differ significantly between municipalities. While some have only a few plans—mainly focused on greening and explicitly referring to GI (e.g., Roeselare), others include references to similar concepts and terminologies, sometimes overlapping in meaning (e.g., Nature-based Solutions), and dispersed across various local and regional planning instruments. A similar degree of heterogeneity was also observed in terms of data availability, both in volume and quality.

The five key topics addressed by the methodology's target maps relate to: implementation scale(s), associated challenges, representation of selected ESS, distribution of GI types, identified unmet demand, and identifying opportunity areas for deploying new GI. Table 6.1 summarises an overall view of the results from implementing the ESPON GILL Methodology in each case study (additional information is provided in the individual Case Study Reports).

Table 6.1
Availability of the ESPON GILL target maps

Case Study		Jastrebarsko		Sopot	Imola		Roese-lare	Tampere	Târgu Mureş
Scale: Urban/ Landscape		U	L	U	U	L	U	U	U
Key Challenge		Access to public GI	Land-slides	Flash flood	Heat stress	Flood risks	Heat stress/ Flood	Heat stress/ Flood	Air pollu-tion/ Flood/ Heat stress
Spatial representation	Challenges	x	x	x	x	x	x	x	x
	ESS	x	x	x	x	x	x	x	x
	GI types	x	x	x	x	x	x	x	x
	Unmet demand	x	n/a	x	x	x	x	x	n/a
	Opportunity areas	x	n/a	x	x	x	x	x	n/a

x = available, n/a = it does not apply

With respect to the **implementation scale**, the methodology proposes using the urban area, the landscape area, or both. In this regard, two of the case studies, Jastrebarsko and Imola, adopted for a dual-scale approach, whereas the remaining cases focused solely on the urban delimitation for quantifying GI demand. However, it is important to note that the selected scale is closely linked to the type of challenge, the municipal goals, and the city's physical characteristics[8].

Regarding the **territorial challenges**—whose identification can be supported by the trigger questions (Annex 2.4—all municipalities defined several challenges, which is an essential step at this stage. Since only a limited number could be selected for timely implementation of the methodology, it was beneficial that the identified challenges were diverse, addressing issues such as accessibility to green spaces, landslides, flooding, heat stress, and air pollution. This diversity enabled us to test the methodology under distinct conditions, applying a variety of methods and using different forms of representation.

For **ESS identification and mapping**, supported by the ESS evaluation factsheets (Annex 2.7), those same challenges served as a reference for selecting the relevant ESS. Although the methodology focuses on five key ESS—carbon storage/sequestration, infiltration/soil erosion, temperature regulation, and recreation/health - additional ESS can also be considered. In some cases (e.g., air pollution in Târgu Mureş, soil erosion in Jastrebarsko), European data sources (Annex 2.2) were used to complement local datasets due to limited data availability at the municipal level. In these mapping exercises, significant differences were spot in the methods applied, the input data used, and the obtained results. While some cases focused on regulating ESS – such as flood control (e.g. Imola) or temperature regulation (e.g., Tampere) – others centred on cultural services, particularly on recreation (e.g., Jastrebarsko). Likewise, whereas in some cases a quantitative characterization of ESS was undertaken using InVEST models (e.g., Sopot and Imola) or based on look-up tables (or conversion tables) (e.g., in Roeselare and Târgu Mureş), in other cases, a qualitative characterization was developed through participatory mapping approaches (e.g., Jastrebarsko).

GI distribution also varied considerably across the six case studies. While some were built using a single layer extracted from a specific plan, others relied on a combination of maps compiled from multiple plans, sometimes spanning different territorial levels, which increased the effort required to construct this output (e.g., Tampere[9]). In cases of overlapping data sources, common criteria were established to prioritize one source over the other, or a decision was taken together with municipal technicians to decide the most appropriate GI type to consider.

The map resulting from the comparison between GI demand and provision—i.e., **the unmet demand map**—depends directly on the previous steps. Although only one action is defined for generating this map, we consider the result to be fundamental for understanding and quantifying GI demand within a municipality. It is worth noting that the ESS provision-map can sometimes be replicated to also represent unmet demand, removing the need to produce a new output, as it was the case in Imola, Tampere and Roeselare.

The construction of the **opportunity map** depends almost entirely on the municipality's knowledge and its input during discussions to identify GI hotspots and prioritise alternatives. This step was not carried out in all case studies due to project time constraints, and because it requires a more in-depth and structured discussion with the case study teams. Among the cases that completed this step in ESPON GILL, Jastrebarsko organised an in-person workshop, which generated valuable discussion and guidance, whereas Sopot, Imola, and Tampere undertook this process through online meetings.

[8] In municipalities with large rural areas adjacent to metropolitan regions, where transportation routes experience high traffic volumes, landslides affecting connectivity may become a priority, making the landscape scale the most appropriate. Conversely, in large southern European cities facing prolonged summer heatwaves and urban heat islands, cooling the urban core may be more critical, thus justifying the urban scale as the most suitable. In cases where the urbanized area occupies the entire municipal territory, the urban scale will be the only viable option.

[9] Combination of Public Parks and Greenbelt layer for the City of Tampere with Open Street Map data (OSM, 2025). Additionally, the national landcover layer and the national agricultural land layer have been used to complete the GI layer and to check the OSM data. Areas below 1,500 m² have not been included (this includes street green verges amongst others). Please consult the Tampere Case Study Report for references and detailed information.

The final stage of the methodology consists of developing recommendations on **how to effectively integrate the prioritised GI deployment map into local planning instruments.** This step represents a return to the initial stages, revisiting existing plans and their GI-related objectives, and identifying which instruments could incorporate the outputs and in what way. Achieving this requires thorough discussions with municipal teams in a collaborative environment, with the aim of defining the actions needed to embed the maps into planning debates, revisions, or specific plans.

Since this process requires a long-term implementation schedule and deeper local team engagement, consequently, it was only partially implemented in the case studies, as evidenced by the insights obtained in the final discussions with the local teams.

In general terms, the heterogeneity of the ESPON GILL case studies presented in this work represents an opportunity to test the methodology in a variety of contexts (e.g., different spatial scales, diverse ESS, amounts and proportions of GI and land-use, various climate hazards, multiple socio-economic contexts), demonstrating that it can be applied by a diverse range of municipalities, while producing valuable and robust outputs in the most practical way possible. The case study teams shared their impressions and expressed their satisfaction with participating in the consortium and contributing to the validation of the ESPON GILL Methodology (conclusions from the final SHC held in January 2026).

For each case study, individual reports were developed, including the contextualisation, inputs, methods and results for each activity within each module, enabling and limiting factors for GI implementation, and overall conclusions from the implementation of ESPON GILL Methodology. The content was complemented with the reactions and reflections collected during the three SHCs.

A dashboard is also available for each case study to enhance the wide and visual comprehension of each applied step of the methodology, which are included as part of the User Manual.

7. ESPON GILL Dissemination

An effective **dissemination of the ESPON GILL results** – in this case, of the ESPON GILL Methodology and the corresponding User Manual – is essential to ensure its wide usability and to build its legacy.

As a complement to the general outreach activities of ESPON GILL as an ESPON Targeted Analysis, we have been disseminating the partial results through several targeted actions, aiming to increase its visibility and making it known among as many local-level decision-makers and practitioners as possible. The events on which we have participated and shared ESPON GILL so far were:

- **Greening Cities Partnership online meeting (24 April):** invitation to present the proposal for the methodology, and the steps to be taken in the development of ESPON GILL.
- **ESPON Seminar in Gansk-PO (15-16 June):** although the consortium members were not present, the officer shared the QR-code to invite the audience to input their nature plans in the good practice repository of the project. From there, the connected individuals have opportunity to learn more about the project.
- **NetworkNature+ Annual Meeting, Brussels-BE (16 September):** participation to understand the inputs from researchers on NbS and contribute to the understanding on how the guide can incorporate the most recent scientific findings.
- **European Week of Regions & Cities, Brussels-BE (14-15 November):** presentation of ESPON GILL Methodology highlighting mainly the insights into the methodology and its structure, and how cities can apply it in practice.
- **ESPON Seminar in Aalborg-DE (19-20 November):** parallel workshop to present the advances of the project and discuss its development with ESPON READAPT and a panel of planning-related experts.
- **ESPON Ireland Event – *NbS & BGI* (3 December):** aimed at considering what approaches have been adopted to date in both planning and implementing nature-based adaptations including blue and Green Infrastructure and the key drivers behind this investment.
- **ESPON Belgium Event - *Urban Greening and No Net Land Take – Contradictions and Opportunities*, Ghent-BE (9 December):** presenting the ESPON GILL Methodology as the starting point for a session titled *"The need for urban Green Infrastructure."*, followed by interventions from Belgian voices dealing with urban greening in practice. The Jastrebarsko Case Study was presented.
- **ESPON Croatian Event - *International Conference: Planning and Development of Resilient Settlements, Zagreb-HR* (10-11 December):** invitation to present the ESPON GILL as a tool for supporting spatial planning in the development of resilient settlements with the application of innovative approaches, The Jastrebarsko Case Study was presented. The project was represented by a member of ESPON EGTC.

The consortium will keep seeking for opportunities to disseminate the ESPON GILL Methodology within the EU Arena, especially with ESPON Community (ESPON Seminars, ESPON National Events, ESPON Thematic Workshops, etc.). In the medium-term, it is also expected that the team works in a scientific publication focused on this methodology and results of the implementation in the six case studies.

8. Key remarks and recommendations

8.1 Enablers and barriers to implement the methodology

As part of the case study development, the six case-study leaders identified factors that enable or hinder GI development, which could affect the implementation of the ESPON GILL Methodology and the further operationalisation of its results into local planning and development.

An initial set of enablers and barriers provided from the ESPON GRETA study (at national level) was updated and enriched during the case study development either through desk research (literature review, policy analysis) or direct inputs from the local teams. The identified factors were aggregated and categorised in seven domains: institutional and organisational, engagement and coordination, political, socio-cultural, biophysical, knowledge, and financial.

Representatives from the six case studies have provided feedback on the compilation of key enablers and barriers (Figure 8.1) gathered from individual reflexions within the development of the ESPON GILL (specific case study enablers and barriers are detailed in the individual case study reports).

The main remarks are:

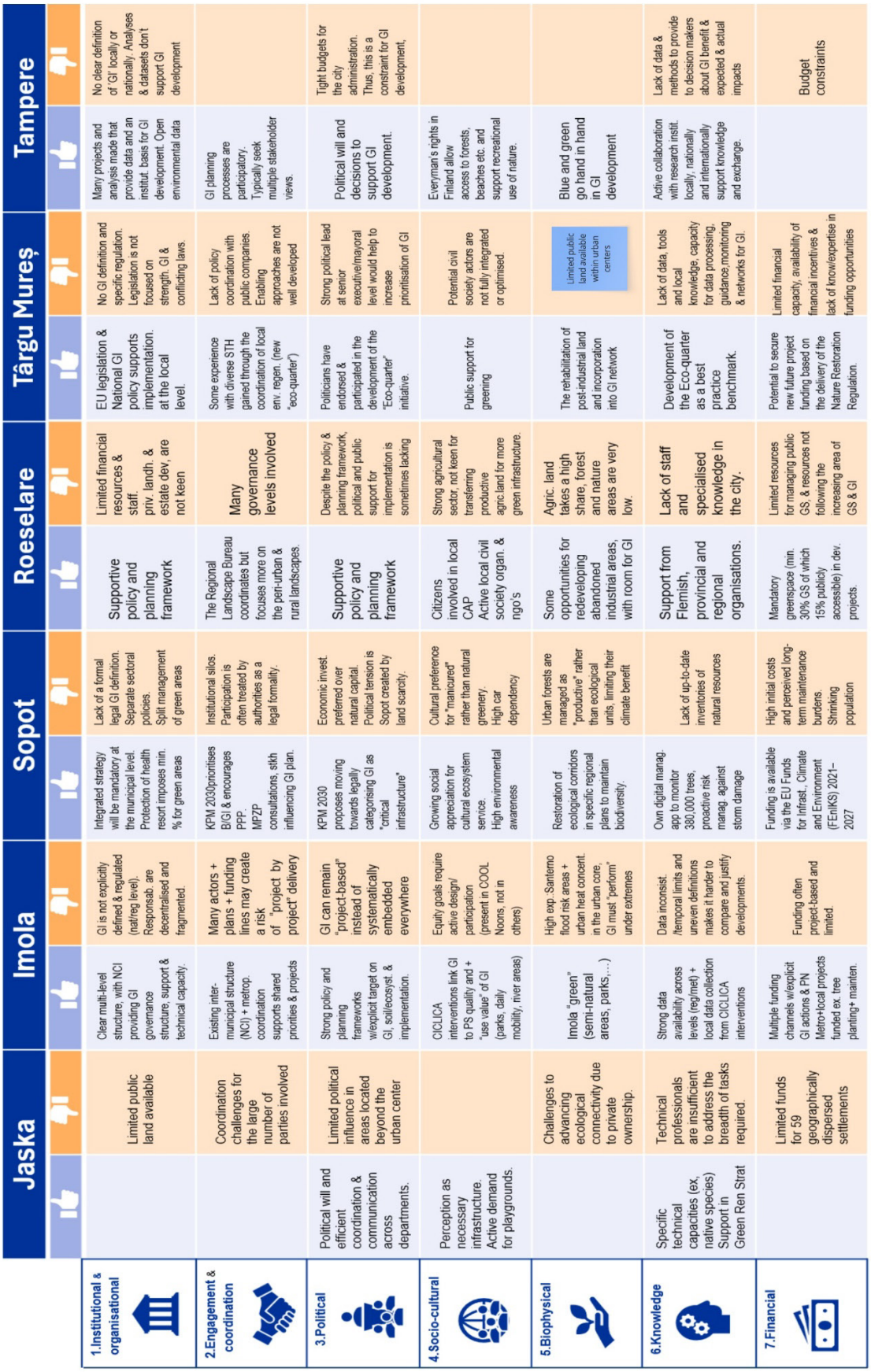
- **Political will vs. Systematic embedding**: There is a clear presence of strong political will and mayoral leadership that prioritizes GI as a necessary infrastructure. However, a critical risk persists where GI initiatives remain "project-based" instead of being systematically embedded across all urban planning sectors. This suggests that while individual flagship projects may succeed, the long-term transformation of urban landscapes requires deeper institutional integration.
- **Governance gap**: although supportive policy frameworks and inter-municipal structures facilitate coordination, they are often undermined by decentralized and fragmented responsibilities across departments. Insufficient coordination with public bodies leads to underdeveloped enabling approaches, highlighting a need for more unified governance models.
- **Financial and land constraints**: A well-known tension exists between high public demand for green spaces and the limited availability of public land within urban cores. Furthermore, while some funding channels are available for the initial implementation of GI, the lack of sustained maintenance resources and tight municipal budgets create a "funding cliff" that threatens the longevity of these natural assets.
- **Data and knowledge hurdles**: While cities benefit from strong data availability at regional and local levels, the effectiveness of this information is often hampered by data inconsistencies and uneven definitions. Overcoming these technical barriers is essential to justify GI developments to decision-makers and private stakeholders, such as developers, who may currently be reluctant to meet GI requirements.
- **Resilience as a driver**: The ability of GI to perform under new climate extremes, such as managing flood risks and urban heat, serves as one of the most compelling biophysical enablers. This functionality positions GI not just as an aesthetic amenity, but as a critical tool for urban resilience, which may help in securing the diverse funding opportunities and political support needed to overcome existing barriers.

The conclusions follow the expected tendency: while multi-level governance structures, EU legislative and funding support, and high public demand serve as powerful enablers, the transition to resilient urban landscapes is frequently stalled by regulatory fragmentation, lack of standardized GI definitions, and technical and financial constraints.

This synthesis consists of a high-level analysis that provide considerations on how cities can leverage existing political will and participatory processes to overcome "project-by-project" delivery of GI implementation, and, instead, move toward a more systematic model of green development based on ESS that secures long-term climate and social benefits.

Figure 8.1

Compilation of case studies enablers and barriers for deploying GI



8.2 Recommendations for future research and policy

In the current European policy landscape, the prominence of the GI concept has diminished compared with the previous decade. Within contemporary biodiversity policy, the EC´s primary focus lies in implementing the NRR through the National Restoration Plans and the UNPs. While these instruments incorporate elements of GI, the concept is also addressed across several other policy frameworks, including the EU Biodiversity Strategy, the EU Forest Strategy, the Climate Law, and the Water Framework Directive.

Similarly, the analysis of planning and policy frameworks undertaken in the ESPON GILL case studies indicates that GI-related provisions are spread across multiple policy domains. This fragmentation, combined with often weak coordination between these domains, and the policy associated to them, can result in GI being assigned a low implementation priority and in missed opportunities to enhance urban liveability through integrated GI approaches. **Understanding possible synergies and trade-offs through the improvement of vertical policy coherence, and policy integration can strengthen the governance structures related to GI, and therefore, enable nature-positive implementation approaches across municipalities through the establishment of multidisciplinary municipal groups**, e.g., "Local Green Deal Action Group" in Mannheim (Germany).

The multilevel policy coherence also can improve legitimacy, linking local action on EU-level commitments, across regional and national scales. A further key outcome of the ESPON GILL process is clear evidence of a lack of data at an appropriate spatial resolution. None of the case study areas possessed an existing GI map. Consequently, the consortium developed local GI maps by integrating a wide range of data sources, including local datasets (e.g., municipally managed greenspaces and land-use zoning maps), regional and national layers (e.g., forest layers, agricultural layers, orthophotos), as well as European (e.g., Urban Atlas) and global datasets (e.g., OpenStreetMap, Google Satellite). **Considering this, additional technical solutions for incorporating and merging data from different sources and scales should also be further investigated.**

A specific challenge in GI mapping arises from the fact that GI elements are characterised through both land-cover attributes (e.g., agricultural land) and land-use functions (e.g., allotment gardens). This could be significantly improved by **developing a harmonised, European-wide GI map, as high-resolution local information** which is essential to produce locally meaningful outputs.

Although the Urban Atlas was used in several ESPON GILL case studies, its last update in 2018 limits its current usefulness. The CLCplus Backbone dataset (latest release 2023) offers a more recent alternative, yet it lacks key features that historically made the Urban Atlas valuable for GI mapping and monitoring—most notably the Street Tree Layer and its vector-based format. **Reintegrating these functionalities into the CLCplus Background dataset would substantially support local authorities, particularly in fulfilling the monitoring and reporting obligations set out under Article 8 of the NRR.** These obligations include assessments of urban tree cover and urban green space, the latter of which encompasses GI elements such as green roofs and green walls.

In addition to challenges relating to GI mapping, the ESPON GILL consortium also identified considerable **gaps in fine-grained data on environmental challenges and ESS provisioning**. For instance, European-wide datasets on air pollution, urban heat islands or flooding are often available only at resolutions of 5 km or less, rendering them insufficient for local-level GI planning and decision-making.

Ensuring that all local and regional authorities across Europe have access to detailed, standardised datasets would create more equitable conditions for GI mapping, planning, design and monitoring. A harmonised European data provision framework would also reduce costs, increase resource and policy efficiency, and facilitate consistent training, reporting and evaluation efforts within Member States, across cities, and across the Union. Ultimately, **providing local authorities with comparable data and tools could potentially lead to more equal opportunities for citizens,** regardless of the technical capacity, data availability or financial situation of their municipality.

During the ESPON GILL project, several promising online tools were identified, including the Nature Value Explorer (Belgium), the Climate Portal (Belgium), and the Environmental Benefits from Nature Tool (EBNT, UK). These tools enable users to map and visualise environmental challenges or unmet ecosystem service demand, assess existing ecosystem service provision, design GI interventions and model their expected impacts.

Scaling such approaches to the European level – supported by harmonised EU-wide spatial datasets – would offer valuable resources for GI mapping, planning, monitoring and design to local authorities, civil society organisations, developers, citizens and other stakeholders. While high-resolution spatial models might be highly desirable, other semi-quantitative or qualitative approaches can be applied at the EU level to help translate GI types into ESS demand and provision values.

In summary, based on the application of the ESPON GILL methodology in the case studies, the consortium recommends the following actions:

1. **Strengthen the role of GI in the implementation of the Nature Restoration Regulation while integrating context-specific planning processes**, ensuring that guidance for Urban Nature Planning provides a more explicit and substantial focus on GI. Recognising that planning processes are highly context-specific, but needing an EU policy umbrella for guidance, further work should explore how ESS assessments can be tailored to local and regional governance, and to their integration with NRR.
2. **Provide detailed and standardised data layers across the European Union** to support local authorities in mapping and monitoring GI and the respective ESS they deliver. Besides, it would be beneficial to benchmark ESS provision and demand models to enhance transparency, comparability and transferability between regions.
3. **Develop a European-wide online tool for mapping and assessing** current GI, relevant environmental challenges and associated ESS. This tool should also support decision-making, planning and design by enabling users to evaluate the effects of projected GI interventions.
4. **Building data-driven capacities**, since municipalities often lack the technical expertise or institutional support to fully leverage ESS assessments. Future research should explore ways to strengthen capacity in GIS, data analysis and ESS modelling, while aligning priorities among planners, policymakers, environmental officers and citizens. Institutional mechanisms—such as dedicated GI units, formal mandates, or long-term governance structures—can enable sustained investment in GI, improve co-benefits and make GI implementation more attractive and effective. Also, data-driven capacities would improve and make the usage of future EU data and ESS assessment tools more efficient.

8.3 Literature Review – ESPON GILL Annexes

The literature review consists of a **compilation of all references consulted during the ESPON GILL development**, i.e., methods used and proposed, databases assessed, among others. Most of it is embedded within the multiple ESPON GILL Annexes, produced and made available as additional resources along the methodology.

The literature review contains:

- **Bibliographic references** (included in the "References" session of this report): searched as the fundament of the content produced.
- **Compilation of key references related to GI**
  - García Blanco, G., Aguirre-Such, A., García, C. Deserti, A. Maria Bellè, B. Puerari, E. (2025). UNPplus Spatial Planning Scheme (D3.1). Urban Nature Plans plus Horizon project.
  - Hansen, R., Rall, E., Chapman, E., Rolf, W., Pauleit, S. (eds., 2017). Urban Green InfrastructurePlanning: A Guide for Practitioners. GREEN SURGE. *Urban Green Infrastructure Planning: A Guide for Practitioners*. Available from: https://www.researchgate.net/publication/319967102_Urban_Green_Infrastructure_Planning_A_Guide_for_Practitioners
  - Remme, R., Paling, N., Bruen, A., De Vreese, R., Deserti, A. et al., Handbook of tools for informing and monitoring urban greening strategies and nature plans, Cortinovis, C., Orta-Ortiz, M.S., Vasilakopoulos, P. and Velasco Gomez, M. (editors), Publications Office of the European Union, Luxembourg, 2025, https://op.europa.eu/en/publication-detail/-/publication/db2d38bd-c5bd-11f0-8da2-01aa75ed71a1/language-en, JRC144165.

- **Annex 1.1. ESPON GILL Glossary:** Provides a list of related terms and their definitions used in the development of the ESPON GILL Methodology, with the aim of offering guidance on the terminology applied.
- **Annex 1.2. Enablers and barriers:** Provides an overview of enabling factors (supportive policies, funding, and stakeholder engagement approaches) that can accelerate GI adoption, as well as barriers (regulatory constraints, financial limitations, and lack of expertise) that may hinder progress across different dimensions (institutional and organisational; engagement and coordination; political; socio-cultural; biophysical; knowledge; and financial). The document is based on practice-based knowledge and lessons learned from the implementation of the ESPON GILL Methodology in case studies.
- **Annex 1.3. Repository of good practices:** This document presents a repository of good practices related to GI-related plans and policies, highlighting successful outcomes in informing urban planning through GI. It includes information on the type of plan, the spatial scale, the responsible authority and location, a brief description, key learning points, contact details, and access to further information.
- **Annex 2.1. Overview of EU policies and legislation with a territorial dimension, or relevant for urban green transition:** This document provides an overview of key EU objectives related to GI, helping local authorities to (i) align their planning goals with EU priorities, (ii) decide which funding mechanisms (particularly the ERDF) they can ascribe to in order to support their investment needs, and (iii) identify data reporting repositories they can access to find relevant data sources.
- **Annex 2.2. List of available European data sources:** This document provides a comprehensive list of European data sources relevant to GI and access to support the application of the ESPON GILL Methodology in municipalities with limited spatial data availability.
- **Annex 2.3. List of data requirements for the ESPON GILL Methodology development:** This document outlines the key data requirements for developing the ESPON GILL Methodology. It identifies the types of data needed (e.g., land-use, socio-demographic information, biophysical hazards) and specifies which module they support. It also provides examples of specific datasets to be potentially used to meet those requirements.
- **Annex 2.4. Trigger questions for challenges identification:** This document provides trigger questions to support the assessment of challenges that were preselected in Module 1. It outlines the associated data requirements and the methodologies that can be applied to address each challenge and estimate GI demand. By making data needs and methodological options explicit, this annex enables a more informed selection of challenges for further analysis.
- **Annex 2.5. List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand:** This document provides a curated list of tools that support the modelling, mapping, or assessment of GI demand, provision, and unmet demand. Each entry includes a brief description of the tool and access information. This annex can support the application of Module 2 by providing tools to translate challenges into maps.
- **Annex 2.6. ESPON GILL GI types:** Outlines a structured classification of GI types and subtypes. GI types provide generic categories for GI, while subtypes further specify these classifications. The classification follows the widely accepted GI definition, encompassing green and blue infrastructure across terrestrial, coastal, and marine environments in both rural and urban contexts.
- **Annex 2.7. ESS evaluation factsheets:** This document explains and provides guidance for selected methods for assessing key ecosystem services (flood regulation, carbon sequestration, recreation, and cooling). Each factsheet includes methodology or model used, units, scale, data requirements and sources, steps, degree of uncertainty, and other relevant considerations.
- **List of GI-projects of reference** (included in the "References" session of this report): ESPON GRETA, GREENSURGE, etc.

All the Technical Annexes are delivered as part of the Final Report Package and are available both through a compiled document available for download in the ESPON webpage, or through the User Manual, where the ESPON GILL additional resources are embedded.

9. Conclusions

The process of designing the ESPON GILL Methodology has been an enriching experience for everyone involved. It has fostered both research innovation and practical learning among the technical partners, as well as among the stakeholders engaged across the six case studies.

The testing of the ESPON GILL methodology in the six case studies revealed several key challenges, reflecting the diversity of urban contexts, data availability, institutional capacities, and policy environments across Europe. These challenges highlight the complexities of applying a standardized, evidence-based methodology in real-world, multi-governance settings. The **main challenges** can be grouped into the following categories:

Data Availability and Quality

One of the most significant challenges was the inconsistent and fragmented availability of spatial and biophysical data. While some case studies had access to detailed GIS datasets (e.g., land-use, tree canopy, green space distribution), others faced major gaps in data coverage, outdated records, or limited access to authoritative sources.

The ESPON GILL Methodology shows than data availability is not a mayor limitation for quantifying GI.

Methodological Adaptation and Contextual Sensitivity

Although the ESPON GILL Methodology was designed to be flexible, adapting it to local contexts proved complex. Key issues included:

- Differences in urban typologies and GI definitions (e.g., what constitutes "urban forest" or "green space" in a dense city vs. a suburban or rural-adjacent area).
- Varied policy priorities—some cities focused on climate adaptation, others on biodiversity or public health—requiring tailored assessments of ESS.
- Incompatibility with existing planning frameworks, such as urban development plans or climate adaptation strategies, which sometimes lacked integration with nature-based approaches.

These differences may require iterative customization of the methodology, including the development of local indicators and thresholds, which added time and complexity to the process.

Stakeholder Engagement and Institutional Capacity

Effective implementation of the ESPON GILL Methodology depended on strong multi-stakeholder collaboration:

- Limited capacity among municipal planning departments to engage with scientific tools and data-driven approaches.
- Projection of divergent expectations among stakeholders (e.g., planners, environmental officers, policymakers, and citizens), leading to potential conflicts of priorities and difficulties in consensus-building.
- Inconsistent levels of institutional support, with some municipalities having dedicated GI units and others lacking the resources or political will to participate fully.
- Time restrictions to fully dedicate to the development of the ESPON GILL Methodology.

Integration with Existing Planning Processes

A major challenge was embedding the methodology into existing urban planning workflows. While the ESPON GILL Methodology aimed to be practical and user-friendly, integrating it into routine planning cycles proved challenging:

- Lack of formal recognition of ESS in local policy and budgeting processes.
- Short-term political cycles and competing priorities that undermined long-term nature-based planning.
- Limited mechanisms for translating scientific outputs into actionable policies, such as zoning changes, green space investments, or regulatory frameworks.

This gap between evidence and decision-making highlighted the need for stronger policy linkages and capacity-building to ensure that GI demand assessments inform actual planning and investment decisions.

Technical and Computational Constraints

The use of geospatial modelling tools and data analysis platforms posed technical challenges, particularly in smaller municipalities with limited IT infrastructure or technical expertise:

- Software compatibility issues between different GIS platforms and data formats.
- Need for training in data analysis, visualization, and interpretation of results.
- Time-consuming data processing, especially when combining multiple data layers or conducting scenario modelling.

These barriers reduced the ease of use and scalability of the methodology in resource-constrained settings.

Despite these challenges, the testing phase of the ESPON GILL Methodology provided **valuable insights into the practicalities of scaling up evidence-based GI planning and implementation.** Key lessons include:

- **The importance of early and inclusive stakeholder engagement to build ownership and legitimacy.**
- **The necessity of flexible, modular tools that can be adapted to local contexts without losing scientific rigor.**
- **The critical role of capacity-building and institutional support to ensure successful integration into planning systems.**

Besides, the generation of robust data infrastructure and standardized data formats across Europe, will inform the refinement and scaling of the ESPON GILL Methodology, ensuring it remains a practical, scalable, and policy-relevant tool for European cities committed to nature-based solutions and sustainable urban development.

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ESPON CIRCTER Update. https://www.espon.eu/projects/circter-update-indicators-circular-economy

Annexes

The Technical Annexes of ESPON GILL listed and described below, are developed to support the implementation of the different actions along the development of the methodology. They are available as separate files (when accessed through the User Manual[10]), as well as in a compiled file uploaded in the ESPON website.

Annex 1.1. ESPON GILL Glossary

Provides a list of related terms and their definitions used in the development of the ESPON GILL Methodology, with the aim of offering guidance on the terminology applied.

Annex 1.2. Enablers and barriers

Provides an overview of enabling factors (supportive policies, funding, and stakeholder engagement approaches) that can accelerate GI adoption, as well as barriers (regulatory constraints, financial limitations, and lack of expertise) that may hinder progress across different dimensions (institutional and organisational; engagement and coordination; political; socio-cultural; biophysical; knowledge; and financial). The document is based on practice-based knowledge and lessons learned from the implementation of the ESPON GILL Methodology in case studies.

Annex 1.3. Repository of good practices

This document presents a repository of good practices related to GI-related plans and policies, highlighting successful outcomes in informing urban planning through GI. It includes information on the type of plan, the spatial scale, the responsible authority and location, a brief description, key learning points, contact details, and access to further information.

Annex 2.1. Overview of EU policies and legislation with a territorial dimension, or relevant for urban green transition

This document provides an overview of key EU objectives related to GI, helping local authorities to (i) align their planning goals with EU priorities, (ii) decide which funding mechanisms (particularly the European Regional Development Fund - ERDF) they can ascribe to in order to support their investment needs, and (iii) identify data reporting repositories they can access to find relevant data sources.

Annex 2.2. List of available European data sources

This document provides a comprehensive list of European data sources relevant to GI and access to support the application of the ESPON GILL Methodology in municipalities with limited spatial data availability.

Annex 2.3. List of data requirements for the ESPON GILL Methodology development

This document outlines the key data requirements for developing the ESPON GILL Methodology. It identifies the types of data needed (e.g., land-use, socio-demographic information, biophysical hazards) and specifies which module they support. It also provides examples of specific datasets to be potentially used to meet those requirements.

Annex 2.4. Trigger questions for challenges identification

This document provides trigger questions to support the assessment of challenges that were preselected in Module 1. It outlines the associated data requirements and the methodologies that can be applied to address each challenge and estimate GI demand. By making data needs and methodological options explicit, this annex enables a more informed selection of challenges for further analysis.

[10] Include link to the User Manual: https://gis-portal.espon.eu/arcgis/apps/storymaps/collections/ee359ic1f3a54944aa5f4335296943f1

Annex 2.5. List of tools to support spatialisation of GI demand, GI provision, and GI unmet demand

This document provides a curated list of tools that support the modelling, mapping, or assessment of GI demand, provision, and unmet demand. Each entry includes a brief description of the tool and access information. This annex can support the application of Module 2 by providing tools to translate challenges into maps.

Annex 2.6. ESPON GILL GI types

Outlines a structured classification of GI types and subtypes. GI types provide generic categories for GI, while subtypes further specify these classifications. The classification follows the widely accepted GI definition, encompassing green and blue infrastructure across terrestrial, coastal, and marine environments in both rural and urban contexts.

Annex 2.7. ESS evaluation factsheets

This document explains and provides guidance for selected methods for assessing key ecosystem services (flood regulation, carbon sequestration, recreation, and cooling). Each factsheet includes methodology or model used, units, scale, data requirements and sources, steps, degree of uncertainty, and other relevant considerations.

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