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Inspire Policy Making with Territorial Evidence

Working paper

Territorial potentials for green infrastructure

Introduction

Green infrastructure (GI) is considered a benefit for territorial development because it provides multiple functions within the same spatial area. The underlying principle of GI is that the same area of land can offer many environmental, social, cultural and economic benefits at the same time, provided its ecosystems are in a healthy condition. However, valuable European ecosystems are being degraded by land fragmentation, urban expansion and the building of transport and energy infrastructures. This affects habitats and species and reduces the spatial and functional coherence of the landscape. Degraded ecosystems have lower species richness and are unable to offer the same services as healthy ecosystems. That is why the EU in 2011 adopted its biodiversity strategy, which aims to ensure that *"by 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems"*[1]. It also calls on member states to map and assess the state of ecosystems and their services nationally. Responding to the commitment made in the biodiversity strategy, in 2013 the European Commission put forward an EU GI strategy to ensure that the protection, restoration, creation and enhancement of GI become an integral part of spatial planning and territorial development whenever it offers a better alternative, or is complementary, to standard grey choices.

GI consists of ecological networks, made up of areas of natural vegetation, other open space, or areas of known ecological value, and links that connect these areas to one another. GI solutions are particularly important in urban environments in which approximately 70% of the EU population lives. In cities, GI features like green walls and roofs, urban woodlands and garden allotments deliver health-related benefits such as clean air and better water quality. GI also creates opportunities to connect urban and rural areas and provides appealing places to live and work in. Furthermore, the restoration of land in cities can be a cost-effective and economically viable way of making them more sustainable, resilient, greener and healthier.

Local and regional authorities, which are generally responsible for land use decisions, have a particularly important role to play in assessing environmental impacts and protecting, conserving and enhancing natural capital. Incorporating GI into related plans and strategies can help overcome fragmentation of habitats and preserve or restore ecological connectivity, enhance ecosystem resilience and thereby ensure the continued provision of ecosystem services, while providing healthier environments and recreational spaces for people to enjoy. In this context, GI can also be seen as a provider of nature-based solutions that are crucial in tackling societal challenges such as unsustainable urbanisation and related human health issues. However, as a study for DG Environment[2] found, one major barrier to the deployment of GI is the insufficient understanding amongst stakeholders of the way natural ecosystems function, which often results in an underused potential for GI development. Better use of integrated spatial planning processes, improved capacity of decision-makers and better institutional cooperation are important elements to address this challenge.

[1] *COM (2011) 244 final, Our life insurance, our natural capital: an EU biodiversity strategy to 2020*

[2] *European Commission/Trinomics B.V. (2016): Supporting the Implementation of Green Infrastructure. Rotterdam*

A variety of studies on GI, ecosystem services and biodiversity aspects have been conducted over the past years throughout Europe. Nevertheless, knowledge and data gaps still exist. Likewise, there is a need to provide quantitative and qualitative evidence on (a) the assets regions and cities have regarding existing green infrastructure and ecosystem services and the access to them, and (b) the demand for these elements, especially in highly urbanised areas[3].

This working paper is guided by the following questions:

- What are potential positive and negative effects of GI and ecosystem services on European territorial development?
- What does the geographical distribution of GI and ecosystem services look like in European cities and regions?
- How can European cities, regions and national governments be supported in making full use of their GI and ecosystem services development potential?

Unless indicated differently, this working paper is based on the draft results of the GRETA (GReen infrastructure: Enhancing biodiversity and ecosysTem services for territoriAl development) applied research project. GRETA provides a novel methodology for analysing the spatial distribution of GI, responding to the three key GI principles of connectivity, multifunctionality and spatial planning and management.

[3] http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/102.pdf

KEY POLICY MESSAGES

- GI can be used as an instrument to support policy objectives e.g. in relation to climate change and biodiversity protection. A connected and multifunctional GI network contributes to mitigating long term environmental challenges, reducing risks, and anticipating unwanted impacts from unsustainable economic trends.
- The lowest percentage cover of potential GI network can be found in the North-West of Europe, where land-use is the most intense and natural ecosystems are fragmented. The maintenance of existing GI, the improvement of connectivity between protected areas and restoration of natural and semi-natural areas are particularly important there.
- In many cases where potential GI is low or disconnected, agricultural areas could be turned into complementary elements of the GI network, depending on their use. This is also an opportunity to greening agriculture in a more integrated way.
- The Nordic countries, the Balkan countries along the Adriatic Sea and the eastern Alpine region display the highest potential for GI networks but have the lowest share of protected core areas. This requires priority actions for the conservation of unprotected links in those regions.
- Cities in eastern and southern Europe, the Netherlands and Finland have experienced a strong loss of green spaces between 2006 and 2012. In the context of climate change mitigation and adaptation, these cities need to focus on strategic, cross-sector planning to reverse these critical development trends and cater for their sustainable development.
- The identification and quantification of benefits of green infrastructure is key in improving stakeholders' understanding of the environmental, social, and economic motivations for implementing green infrastructure.
- Accurate and updated spatial data on potential green infrastructure networks should inform evidence-based decision making on where to invest resources, particularly for identifying green infrastructure 'hot spots' that either require increased safeguarding or restoration.
- Policy integration is vital to further embed green infrastructure in relevant policy domains where it is not prominent yet, like in finance, energy, health, and social services.
- There is a need for further collaboration, awareness and capacity building, and knowledge exchange to build a common understanding between professionals operating at different implementation stages and scales.

1. Green infrastructure – what are we talking about?

Green infrastructure (GI) is generally 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 (ES). It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings.”[4]

This definition embraces three aspects that are important for effective GI implementation into sectoral policies:

(i) **connectivity**, the idea of a network of geographical areas;

(ii) the concept of **multifunctionality** i.e. the idea of the same geographical area being used for several purposes/activities and, at the same time, also supplying multiple ES[5]; and

(iii) the component of **spatial planning and management**.

Underlying the concept of GI is the recognition of the environment as an infrastructural resource capable of delivering a wide range of ecosystem services. People benefit in various ways from ecosystems and the services provided by them. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disesase; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.

Case study: the Alps as providers of ecosystem services

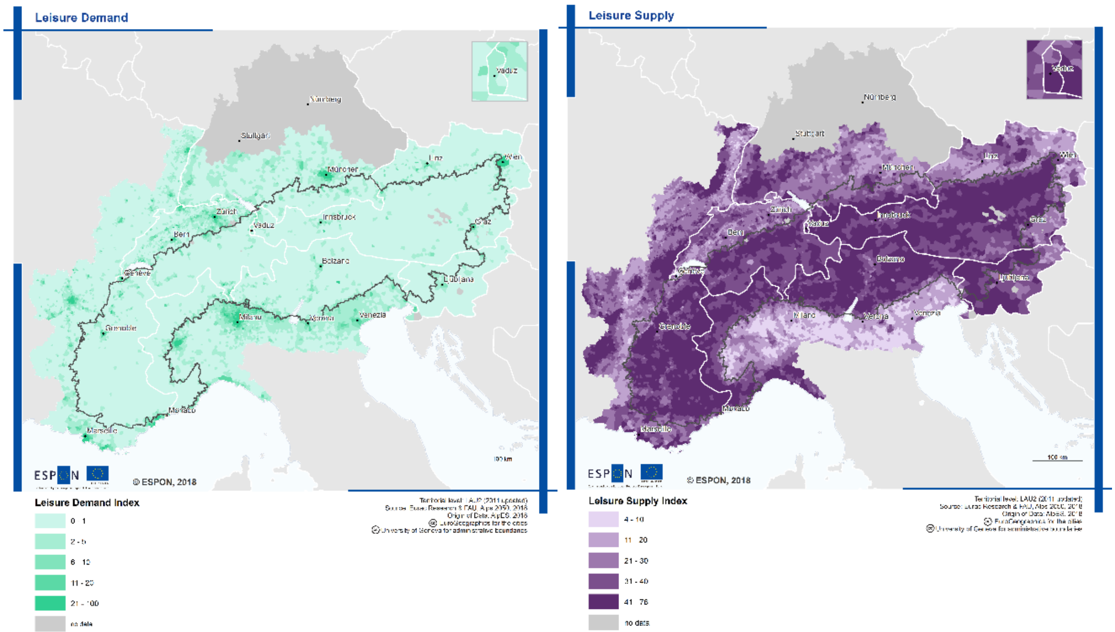
The Alpine mountains are a particular geographical space, embodying spectacular landscape features, precious cultural heritage, and a touristic destination of global importance. It is an overall prosperous region but also an ecological hot spot, diverse, unique, and vulnerable. Sustainable development of this sensitive area is a particular challenge for regional policies. Balancing development opportunities and protection regimes is a fundamental challenge and a strategic requirement: maintaining prosperity and quality of life, ensuring innovation, managing settlement expansion, responding to climate change, reducing fragmentation of ecosystems, steering agricultural transformation are just some of the most important issues at stake in the political agenda.

The maps below reveal the significance of the Alps as a healthy ecosystem for the urban agglomerations in the surrounding macro-region. The demand for recreation opportunities derived from nature is located in those places, where population density is very high. Leisure supply, though, is mostly concentrated in mountainous regions. Likewise, the demand for water is very much linked to the urban and metropolitan nodes. Organising these spatial patterns with political and spatial development tools is a major challenge for the Alpine region.

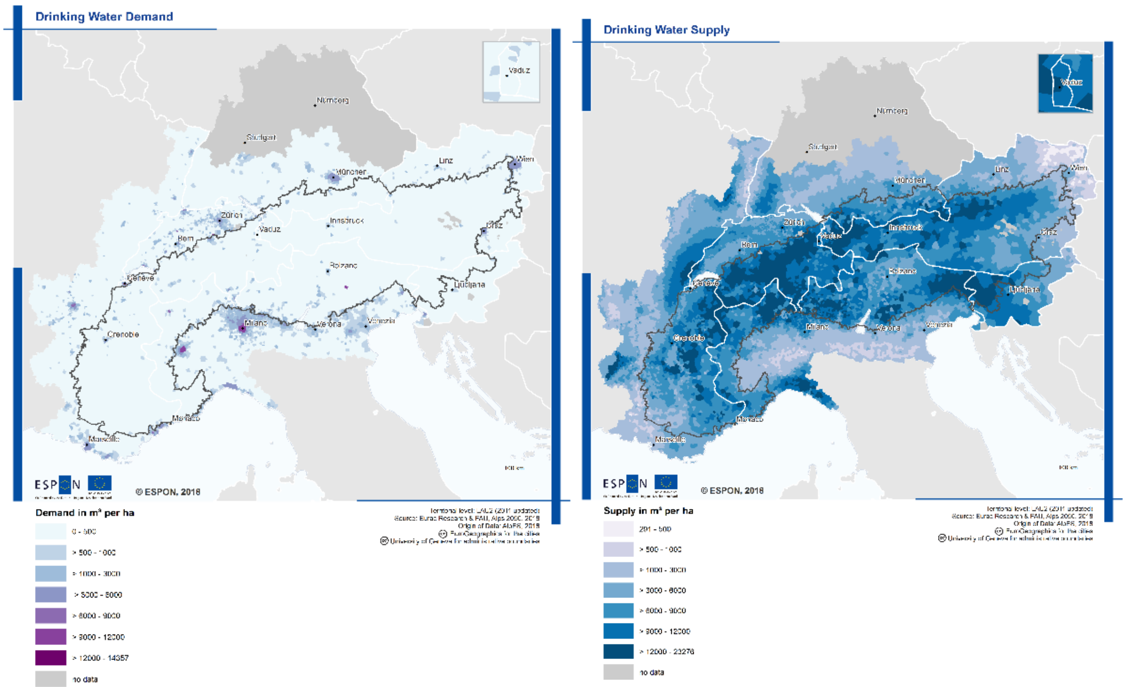
[4] *COM (2013) 249 final, Green Infrastructure (GI) – Enhancing Europe’s Natural Capital*

[5] *There is not a unique relationship between land use and ecosystem services.*

Map 1: Leisure demand and supply as ecosystem service



Map 2: Demand and supply of surface water as ecosystem service



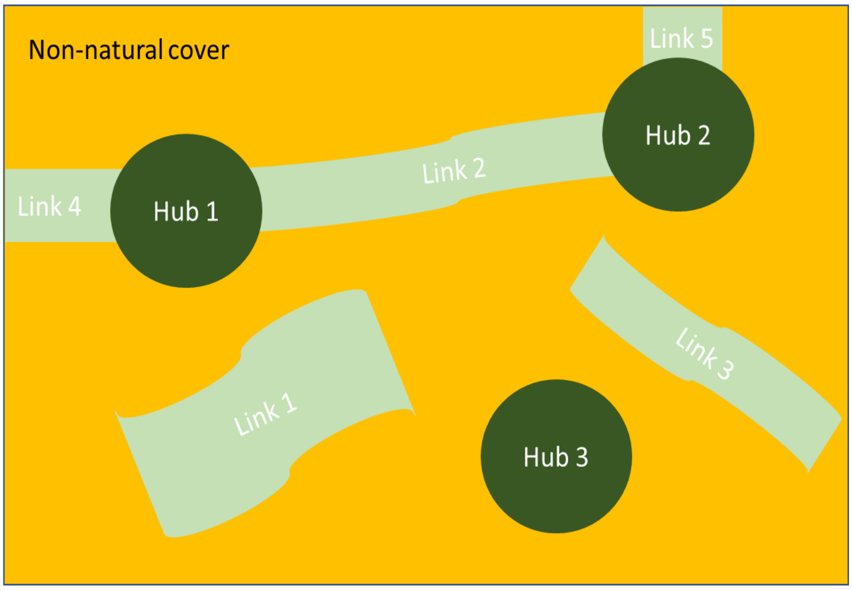
Source: Alps2050, 2018

Many different elements contribute to a GI network, including large scale ‘core areas’ or ‘hubs’ like nature reserves, water or landscape protection areas, Natura 2000[6] sites; and smaller scale ‘corridors’ that link the core areas. Corridors can be made up of pastures, woodland, forests, ponds, bogs, rivers and floodplains, wetlands, lagoons, beaches, hedgerows, stone walls, wildlife strips, riparian river vegetation.

[6] Natura 2000 is a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right.

The figure below illustrates the connectivity concept between ‘hubs’ and ‘links’ that guides the final physical structure of a potential GI network at landscape level. In this example, ‘Hub 1’ and ‘Hub 2’, connected by ‘Link 2’, are conceptually part of the final potential GI network whereas ‘Link 1’ and ‘Link 3’, as well as ‘Hub 3’ would not be included in the GI network. In this situation, the role of spatial planning would be to ensure the creationg of links with the non-connected hubs and links to arrive at a better functioning GI network.

Figure 1 Illustration of connected ‘hubs’ and ‘links’ in the wider landscape



Source: GRETA, 2018

A system of protected areas, i.e. hubs, that comprises two or more such areas sharing common goals, is considered a network of protected areas (NPA). An NPA can be seen as a governance instrument to ease the coordinated management of protected areas, which require joint actions for their conservation and valorisation. NPAs can be institutional or non-institutional, built around different objectives and managed according to an ecological perspective or a wider cooperation-based approach. One aim of NPAs is the facilitation of nature conservation in cases where species or habitats are found in more than one geographic location.

Ideally, the concept of GI forms an integral part of spatial planning and territorial development policies. At the moment, GI is most prominently integrated into the following policy sectors: land use and spatial development planning; water management; agriculture, forestry, and fisheries; climate change mitigation and adaptation; environmental protection; biodiversity conservation; and rural development. It is less prominent in finance; energy; health; and social services.

2. Potential positive and negative effects of GI and ecosystem services on territorial development

GI is generally acknowledged to maintain natural ecological processes thereby improving long-term ecological resilience and protecting biodiversity. It sustains water, air and other natural resources, and contributes to healthier societies increasing the quality of life of citizens. This multifunctional character of GI often provides cost-effective alternatives to traditional 'grey' infrastructure.

The benefits derived by GI and ecosystem services often appear in bundles, and under certain circumstances, are mutually reinforcing. Ecosystem services can interact with one another and cause changes in one service to alter the provision of another one. Depending on the relationship between pairs or bundles of ES, there can be 'trade-offs' (i.e. one ES responds negatively to a change of another ES), 'synergies' (i.e. both ESs change positively in the same direction) or no effects at all.

The relationship between a pair of ES can differ across different scales and across different socio-ecological systems. An example of this is the "externality" of a decision on a certain service, meaning a decision that seems to influence ESs positively for a specific region might cause substantial trade-offs in areas nearby or faraway. If the effects of this decision are viewed at a larger scale, including all those negatively influenced areas, the relationship between ES might be characterized by a trade-off.

Simultaneous maximisation of all potential benefits to different policies from GI is unlikely, thus trade-offs need to be assessed. GI networks need to be strategically planned in a way that conservation, protection, and restoration of ecosystems are taken into account to maximise the benefits that can be obtained. Furthermore, linkages, complementarities and contributions to different policy sectors should ideally be realized.

Table 1 below provides an overview of some generalisations that arise from a comprehensive literature review. The urban and peri-urban scale refer to Functional Urban Areas (FUAs), understood as the core city (i.e. a local administrative unit in which most of the population lives in an urban centre of at least 50 000 inhabitants) plus its associated hinterland. The landscape scale refers to the regional scale outside the FUAs.

Table 1 Summary of main benefits provided by Green Infrastructure at different scales

<table>
<tr><th>Topics</th><th>Urban and peri-urban</th><th>Landscape</th></tr>
<tr><td rowspan="3">Biodiversity and species protection</td><td colspan="2">Habitats for species</td></tr>
<tr><td></td><td>Permeability for migrating species</td></tr>
<tr><td colspan="2">Connecting habitats</td></tr>
<tr><td rowspan="4">Climate change adaptation</td><td>Mitigating urban heat island effect with evapotranspiration, shading and keeping free corridors for cold air movement</td><td></td></tr>
<tr><td></td><td>Strengthening ecosystems' resilience to climate change</td></tr>
<tr><td colspan="2">Storing flood water and ameliorating surface water run-off to reduce the risk of flooding</td></tr>
<tr><td colspan="2">Coastal protection (sea level rise)</td></tr>
<tr><td rowspan="2">Climate change</td><td colspan="2">Carbon sequestration</td></tr>
<tr><td colspan="2">Encouraging sustainable transport (e.g. walking and cycling lanes)</td></tr>
</table>

<table>
<tr><th>Topics</th><th>Urban and peri-urban</th><th>Landscape</th></tr>
<tr><td rowspan="2">mitigation</td><td>Reducing energy consumption for heating and cooling buildings</td><td></td></tr>
<tr><td></td><td>Providing space for renewable energy like ground source heating, hydroelectric power, biomass and wind power</td></tr>
<tr><td rowspan="2">Water management</td><td>Sustainable drainage systems — attenuating surface water run-off</td><td></td></tr>
<tr><td>Groundwater infiltration</td><td></td></tr>
<tr><td rowspan="3">Pollution reduction</td><td colspan="2">Removal of pollutants from water (e.g. reed beds)</td></tr>
<tr><td>Air quality improvements</td><td></td></tr>
<tr><td>Noise attenuation</td><td></td></tr>
<tr><td rowspan="4">Food production and security</td><td colspan="2">Direct food and fibre production on agricultural land, edible gardens and allotments</td></tr>
<tr><td colspan="2">Keeping potential for agricultural land — food security (safeguarding of soil)</td></tr>
<tr><td></td><td>Soil development and nutrient cycle</td></tr>
<tr><td></td><td>Preventing soil erosion</td></tr>
<tr><td rowspan="5">Recreation, well-being and health</td><td colspan="2">Recreation</td></tr>
<tr><td>Sense of space and nature</td><td></td></tr>
<tr><td>Favour physical activity</td><td></td></tr>
<tr><td>Improvement of mental health through stress reduction, increased cognition abilities and restored attention capacity</td><td></td></tr>
<tr><td>Reduced negative health impacts from extreme heat events</td><td></td></tr>
<tr><td rowspan="5">Economic impact</td><td>Positive impact on land and property</td><td></td></tr>
<tr><td>Creation of new jobs</td><td></td></tr>
<tr><td>Reduced energy use</td><td></td></tr>
<tr><td>Reduced potable water use by means of water harvesting</td><td></td></tr>
<tr><td>Avoided grey infrastructure costs and reduced stormwater treatment costs</td><td></td></tr>
<tr><td rowspan="2">Culture and communities</td><td colspan="2">Opportunities for education, training and social interactions
Tourism/visit opportunities</td></tr>
<tr><td colspan="2">Local distinctiveness</td></tr>
</table>

Source: GRETA, 2018

Case study: "Green and Blue Corridor" in the metropolitan area of Lisbon, Portugal

The "Green and Blue Corridor" project concerns the creation of a vast park (Parque Queluz-Jamor) covering an area of approximately 10 km2 shared by the three contiguous municipalities of Sintra, Amadora and Oeiras in the metropolitan area of Lisbon. In July 2016, the municipalities together with the public-owned company Parques de Sintra – Monte da Lua (PSML) signed a joint protocol to collaborate and develop the 'Green and Blue Corridor'. The four actors have commited towards the integrated development of their region to ensure the ecological requalification of the Jamor river and the rehabilitation of surrounding public space. The strategy of a 'blue and green corridor' is intended to improve the connectivity of a dense, fragmented and highly complex suburban territory, whilst facilitating soft mobility between several public facilities adjacent to that corridor. It is also expected to improve several environmental and cultural assets, to add to the quality of life and wellbeing of local residents, and to contribute to tourism development. In the long-term, the project is expected to reinforce the metropolitan green network, contribute to territorial cohesion and reduce the metropolitan carbon footprint. The increase in soft mobility infrastructures and the creation of new urban parks is also expected to improve social cohesion.

The “Green and Blue Corridor” evolved through an adverse conjuncture, shaped by a severe financial crisis, subsequent public-sector budget cuts and investment slowdown. However, the project benefited from a relevant administrative reform in Portugal, aiming at political decentralisation and favouring the formation of supra-municipal bodies. In order to implement “Green and Blue Corridor” in their territory, all three local authorities preferred to use more flexible and swifter operational planning strategies, rather than more conventional planning instruments, which are less adaptable and slower to implement. Essentially, each municipality chose the approach that best fit their existing strategies.

The project clearly embraces a strategic planning perspective with a vision of sustainable mobility and quality of life in suburban areas lacking green and public spaces. It also contributes to climate change mitigation by regularising the river courses, preventing floods and increasing green areas by creating a green corridor – the largest in the metropolitan area. Last but not least, it also stimulates new economic opportunities and internationalisation, by promoting an economy linked to tourism and leisure, based on the natural and cultural landscape, in areas where those activities were scarce.

Furthermore, the “Green and Blue Corridor” contributes strongly to the regional strategy, namely to the objectives of adaptation to climate change, risk prevention and management, environmental protection and the transition to a low carbon economy. First, the intervention on the river regularisation is aiming at preventing floods in the area. Second, the creation of a vast park in the area is contributing to the protection of the environment. Finally, the completion of a network of pedestrian and cycling connections between several facilities adjacent to the corridor is contributing to the transition to a low carbon economy.

Source: ReSSI, 2017

The ability to identify and value benefits is crucial to appreciate GI’s full potential. There are, however, drawbacks that should be properly acknowledged prior to implementation of GI. The analysis of negative impacts of GI on territorial development is still in an early stage. Therefore, there is as yet only limited literature on this topic. Nevertheless, some generalities can be highlighted in the following. Most cited are the ones related to social aspects such as eco-gentrification and the increase of inequalities, risk of vandalism in parks and open spaces, disagreement in stakeholders’ priorities, fear of natural spaces, increased sources of allergies, high levels of heavy metals and other pollutants in agricultural products from community gardens.

Eco- (or green) gentrification occurs when wealthy residents move into historically disadvantaged neighbourhoods after a new green area is promoted or developed. Rents and property values usually increase, forcing the displacement of long-term residents who cannot afford to remain. Moreover, the character of neighbourhoods and community changes through loss of local distinctiveness and cultural heritage. To avoid such drawbacks and to ensure GI benefits are distributed equitably, particularly including vulnerable communities, urban greening needs to be planned considering social justice principles.

Adverse effects on human health from the consumption of food produced in urban sites, via the uptake and accumulation of trace metals in plant tissues, differs according to crop type, species, and plant parts.

There exist significant differences in trace metal concentrations depending on local traffic, crop species, planting style and building structures, but not on vegetable type. While a higher traffic burden increases trace metal content in plant biomass, the presence of buildings and large masses of vegetation, acting as barriers between crops and roads, reduces pollutant content.

Economic disadvantages include **higher costs to initiate and maintain GI** and **higher costs for purchasing or leasing land and properties**. The main issue is often a lack of understanding of multiple benefits that GI provide, which makes it difficult to properly quantify the cost-benefit relation and discourages the implementation at different levels (design, planning and construction) and the management process (long-term funding and maintenance). Putting into practice a 'learning-by-doing' approach, based on scientific results and led by multi-disciplinary teams, has been identified as a key element for unlocking these barriers.

Interestingly, the effect of GI on property prices seems to be higher when the relevant GI includes a water element (river, lake or water structures in urban parks). Other GI types that can typically be found in cities like urban parks, urban forests, or the presence of playgrounds, do not influence property prices in significant different ways. Furthermore, individuals living in highly populated regions do not seem to be willing to pay more for GIs. GIs are valued differently by people depending on the ecosystem services they aim at providing. The highest preference in that respect goes to flood control, but with high variations across different types of regions, recreation services and biodiversity support.

Among the ecological downsides are the **risk of invasion by alien species**, **water pollution from fertilisers and other chemical inputs**, or **higher levels of water consumption**. Urban green spaces have contributed to the introduction of alien species, especially plants, but this is also true for other taxa. Depending on conditions, these species may spread and colonise new areas, becoming invasive. When GI is fully integrated in a network of green areas, GI may act as a dispersal highway for these invasive species.

In summary, the quantification of benefits provided by GI directly depends on the type of assets, their spatial configuration, methodological aspects and other context specificities. Therefore, there is not a single one-fits-all-solution, but rather a suite of approaches that must be tailor-made depending on the context (goals, location, local climate, city/regional structure, among others). Finally, the relationships between GI, biodiversity and ES are dynamic and need to be monitored and examined over longer time periods in order to purpose effective and adequate adaptive management measures.

3. The geographical distribution of green infrastructure and ecosystem services in Europe

The ESPON GRETA (Green infrastructure: Enhancing biodiversity and ecosystem services for territorial development) project elaborated an innovative spatial analysis methodology that allows the standardised comparison of “potential” green infrastructure across European regions and cities. At the same time, the methodology permits an evaluation of the ability of green infrastructure to deliver different policy objectives. This means that the resulting maps represent the potential of the landscape to provide elements that can be used as GI links or hubs, as well as the potential of those elements to provide multiple ES supporting the goals of selected policy frameworks. They do not identify spatial areas already bound by policy measures and secured by their obligations. This important difference needs to be kept in mind when looking at the subsequent maps.

The results at NUTS 2/3 level can help to understand where immediate opportunities exist for GI implementation, and which regions have lower natural capital and protected areas for GI establishment. The understanding of a GI network as a spatial area especially dedicated to the provision of multiple ES, in combination with an accounting of the type of ES that are being provided, can help in identifying potential policy beneficiaries and support their interest and participation in safeguarding or enhancing the provision of ES to achieve their goals

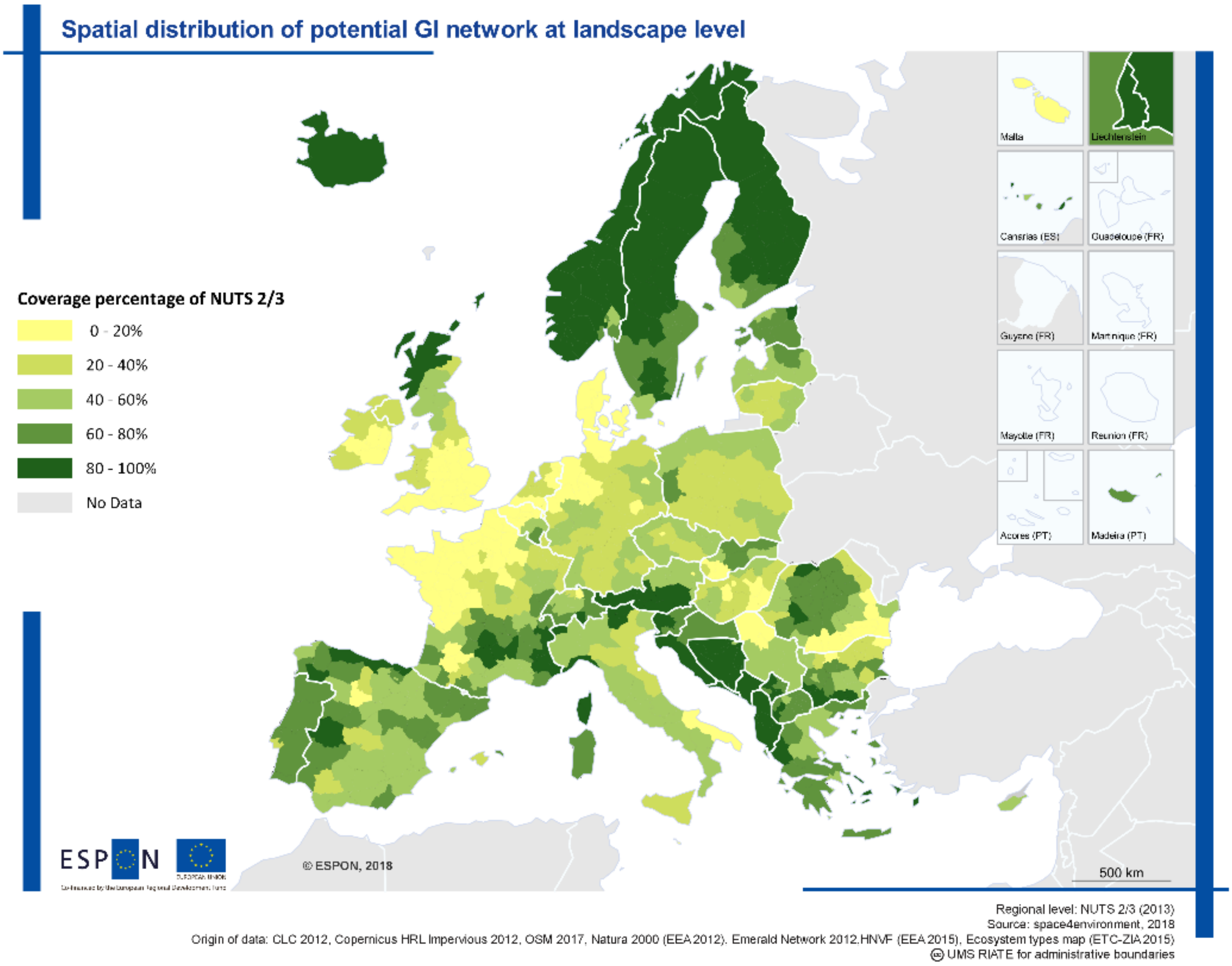
At the city level GRETA also provides an overview of urban GI based on green (and blue) urban areas for all core cities in Europe with an assessment of changes in urban GI between 2006-2012.

3.1 Where is potential GI in Europe’s regions?

Two noticeable patterns can be clearly distinguished in the following map: 1) the very low percentage cover of potential GI in the regions of north-western France and Germany, southeastern UK and Ireland, and Denmark; and 2) the very high percentage cover of potential GI in the Nordic countries, the Balkan countries along the Adriatic Sea and the eastern Alpine region.

The described patterns represent two extreme cases of connectivity between natural ecosystems across EU regions. In the first case, a lack of connectivity, e.g. due to a high degree of built up urban areas, transport and/or grey infrastructure, intensive agriculture, etc., results in fragmented natural ecosystems. In the second case the natural elements in the landscape spread along more spatially contiguous patches covering large areas. This pattern is largely influenced by population density, infrastructure development, climatic and topographic conditions, as well as the distribution of utilized agricultural area in the EU territory. France has the largest agricultural area, followed by Spain, the UK and Germany.

Map 3: Spatial distribution of potential GI network at the landscape level

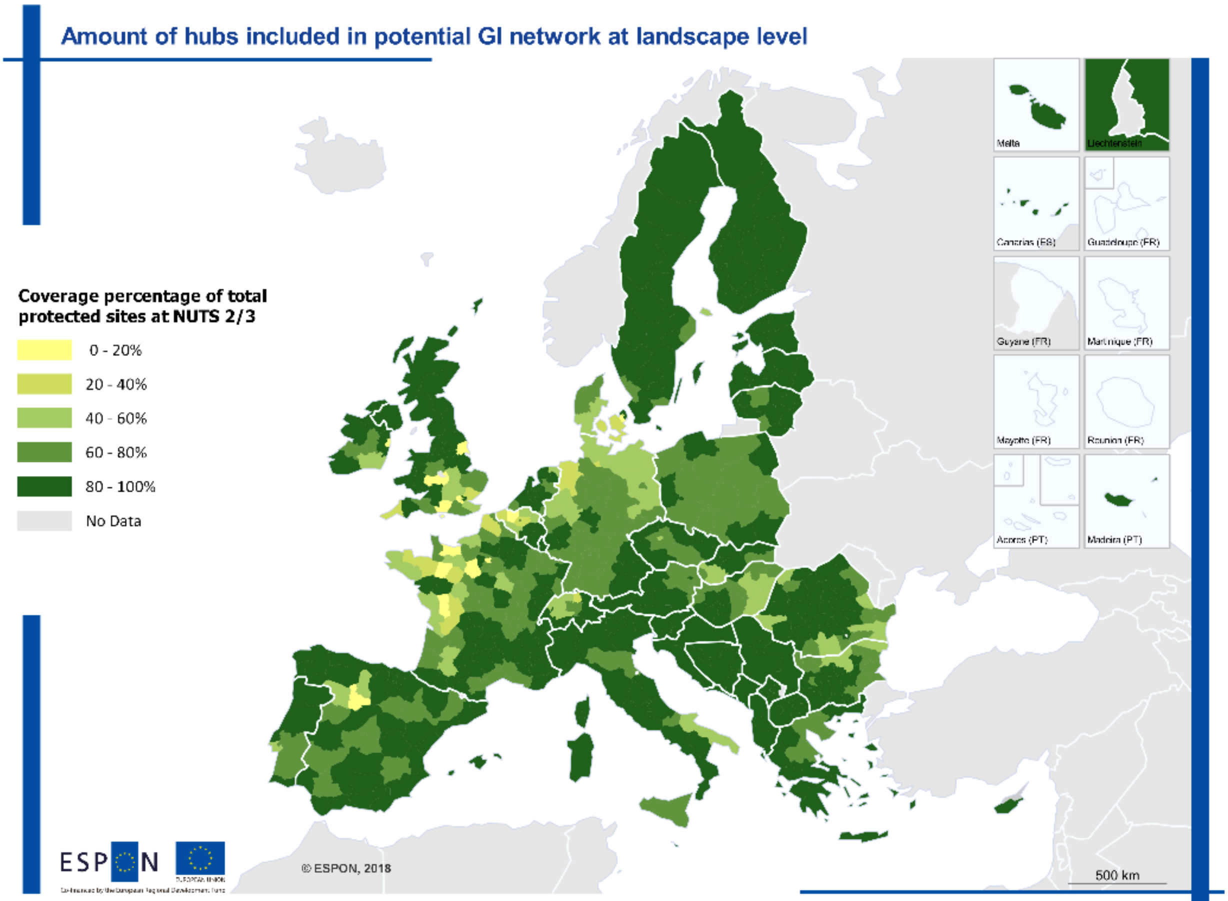


3.2 What is the contribution of protected areas to potential GI?

The following map displays the share of hubs (i.e. European protected sites, namely designated Natura 2000 and Emerald Network sites) that are part of the potential GI network within each NUTS 2/3 region.

Protected areas are key elements of the potential GI network as they contribute to maintaining and restoring the conservation status of habitats. Overall, and for most regions, more than 60% of the protected areas in Europe are connected in the landscape and are considered part of a potential GI network at the regional level. As expected, and based on the results of Map 1, the exceptions to this general pattern occur mainly in north-western France and south-eastern UK. The factor most contributing to this pattern, as mentioned before, is the fragmentation of natural areas in the landscape either by urbanisation or agricultural expansion that impede the connectivity between protected areas.

Map 4: Total amount of hubs (i.e. European protected sites) connected in potential GI network at landscape level



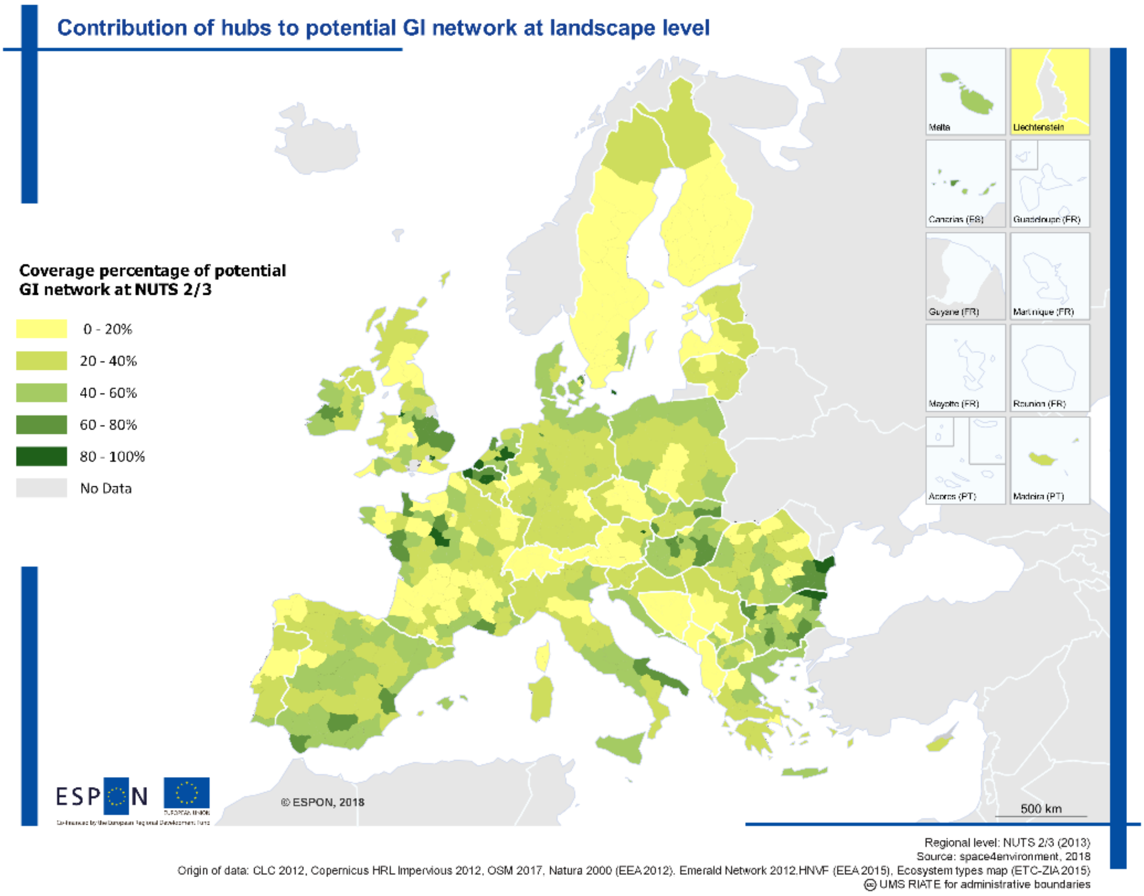
Regional level: NUTS 2/3 (2013)
Source: space4environment, 2018
Origin of data: CLC 2012, Copernicus HRL Impervious 2012, OSM 2017, Natura 2000 (EEA 2012), Emerald Network 2012.HNVF (EEA 2015), Ecosystem types map (ETC-ZIA 2015)
© UMS RIATE for administrative boundaries

3.3 Where is potential GI not connecting protected areas?

Map 3 helps to identify the need for protecting more natural and semi-natural areas included in the GI network. Interestingly, and in contrast to the results presented in Map 2, it can be observed that the proportion of protected areas in the potential GI network is below 40% for the majority of NUTS 2/3 across the EU. This suggests that on average 60% of the potential network at the regional level is composed of unprotected landscape elements that deserve special attention to avoid their conversion into urban or intensively managed agricultural areas.

Regions with a very high percentage cover of potential, such as the Nordic countries, the Balkan countries along the Adriatic Sea and the eastern Alpine region, are among those with the lowest contribution of protected 'hubs' to the total area of potential GI, i.e. less than 20%. This outcome mainly reflects that: 1) these countries are not covered by EU protected areas (e.g. Iceland); or 2) there are differences in the number and extension of protected sites between Natura 2000 and Emerald networks, which is lower for the later. Therefore, although for those regions almost all protected areas are connected through a potential GI network, the total area of the network comprising unprotected "links" is at least 4 times larger than the area of the “hubs” they connect. This means that it is important to give priority to the conservation of unprotected “links” in those EU regions.

Map 5: Contribution of protected ‘hubs’ to the total area of potential GI network at landscape level



3.4 Where is landscape fragmentation an issue to potential GI?

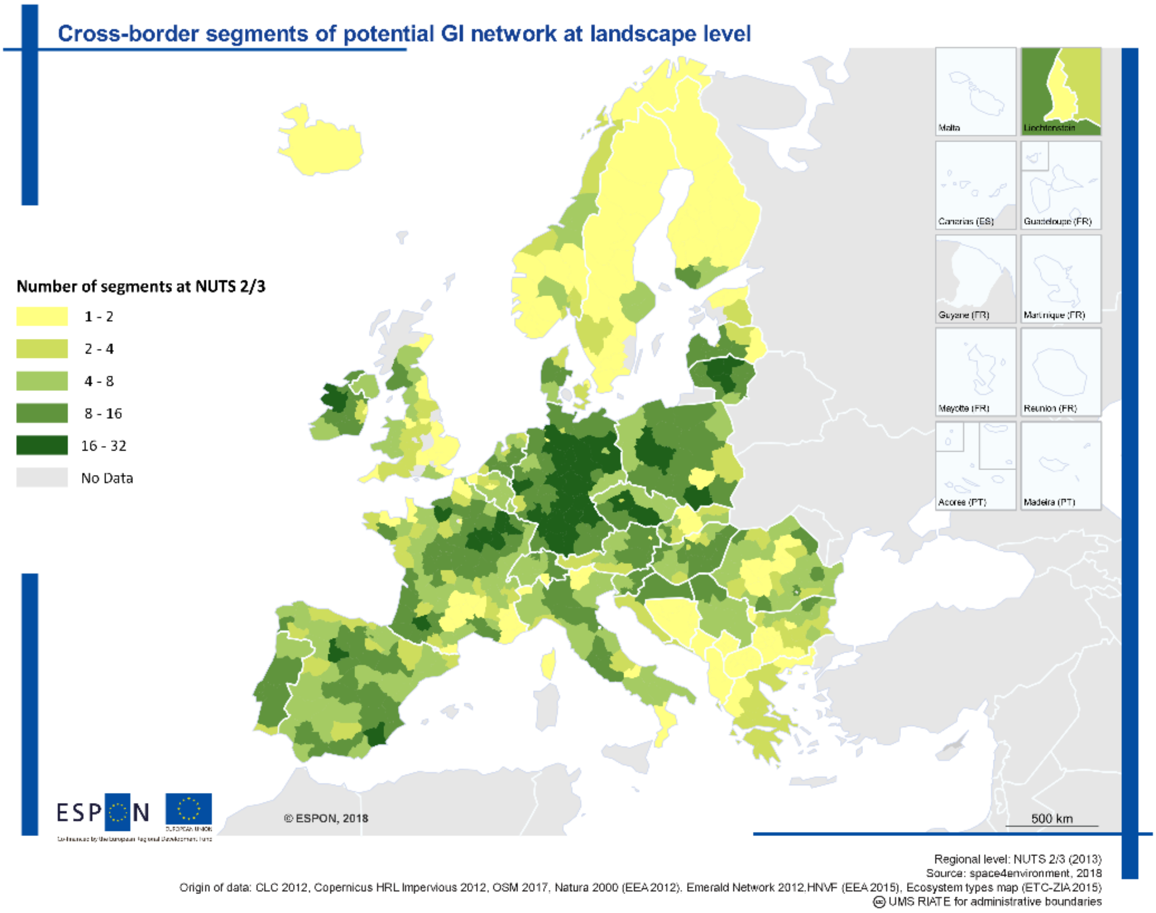
The following map shows for each NUTS 2/3 region the sum of GI sections that are not connected and that cross the border of the region. The higher the connectivity, the less fragmented the GI network as it is mainly constituted by continguous sections that connect one region with at least another region.

The presence of single and continuous network elements is perceptible in the West Balkan countries along the Adriatic Sea as well as in the Nordic countries. A surprising case not perceived in the previous maps is that of Germany. The country includes most NUTS 2/3 regions with the highest number of cross-border GI segments. This reflects the highly fragmented natural landscape, as the country has one of the most closely meshed motorway networks in the world and exhibits one of the highest volumes of passenger and freight transport in Europe[7]. Its central location in Europe, high levels of industrialisation, and the construction of transportation infrastructure explain this high level of landscape fragmentation, which can in the short- to long-term reduce the available area of potential GI. At the same time, as seen in Map 1, the area of potential

[7] https://www.eea.europa.eu/publications/landscape-fragmentation-in-europe

GI in Germany is on average below 40% (and below 20% for the north-western regions). Although more than 60% of protected areas in the country are linked by natural and semi-natural ‘links’, they constitute less than 40% of the potential GI surface. This indicates that on average, more than 60% of Germany’s potential for GI is not protected by EU directives. It is also worthwhile to notice that this pattern is expanding through the French regions bordering Germany, which might indicate a hotspot of transition in the landscape characteristics preventing the deployment of potential GI network.

Map 6: Cross-border segments of potential GI network at landscape level

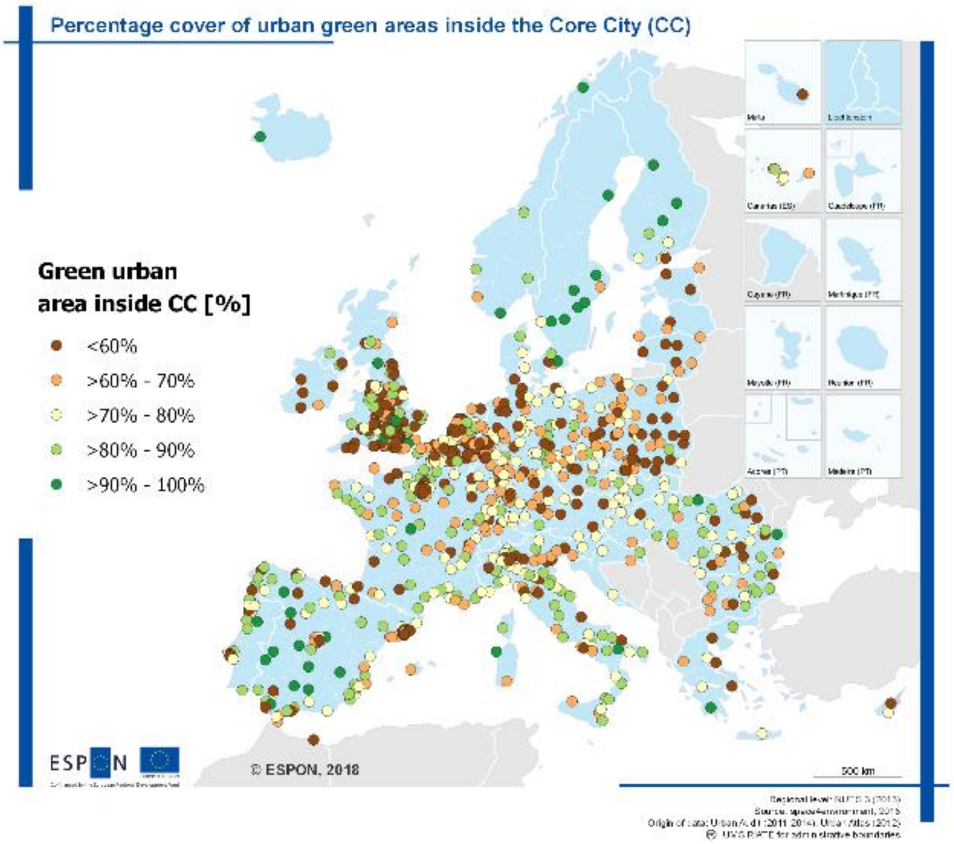


3.5 What is the geography of urban GI in Europe?

The assessment of urban GI includes all available green and blue areas. Map 5 below shows the share of green (and blue) urban areas for all core cities in Europe. Many European cities are relatively green, many possessing more than 80 % green areas. There is a concentration of core cities with lower values in a corridor from the UK over the Benelux countries, Germany to the north-eastern part of Europe (Poland and the Baltic countries).

GRETA analysis also showed that there are clusters of cities with high values of Natura 2000 sites within their FUAs (functional urban areas) in the south of Spain and Portugal, along the Mediterranean coast in France, in a stretch from Greece over Bulgaria into Romania and in south-western and north-eastern Germany. Clusters of cities with low values are located in a zone from the UK to northern France, Belgium, the Netherlands and north-western Germany, in Sweden and Finland, northern Italy, northern Spain and Portugal as well as central Romania. Inside core cities, the share is substantially lower and there are over 260 cities without any Natura 2000 areas. On the other hand, Ioannina (GR) is fully located inside a Natura 2000 site. This highlights the fact that Natura 2000 sites are not only restricted to nature reserves devoid of any human activity, but also include privately owned land with a view to the conservation of the natural resource at the interface between people and nature. It is also worthwhile noting that the manifold functions provided by GI in cities derive not exclusively from Natura 2000 sites but also other green and blue areas, as highlighted above.

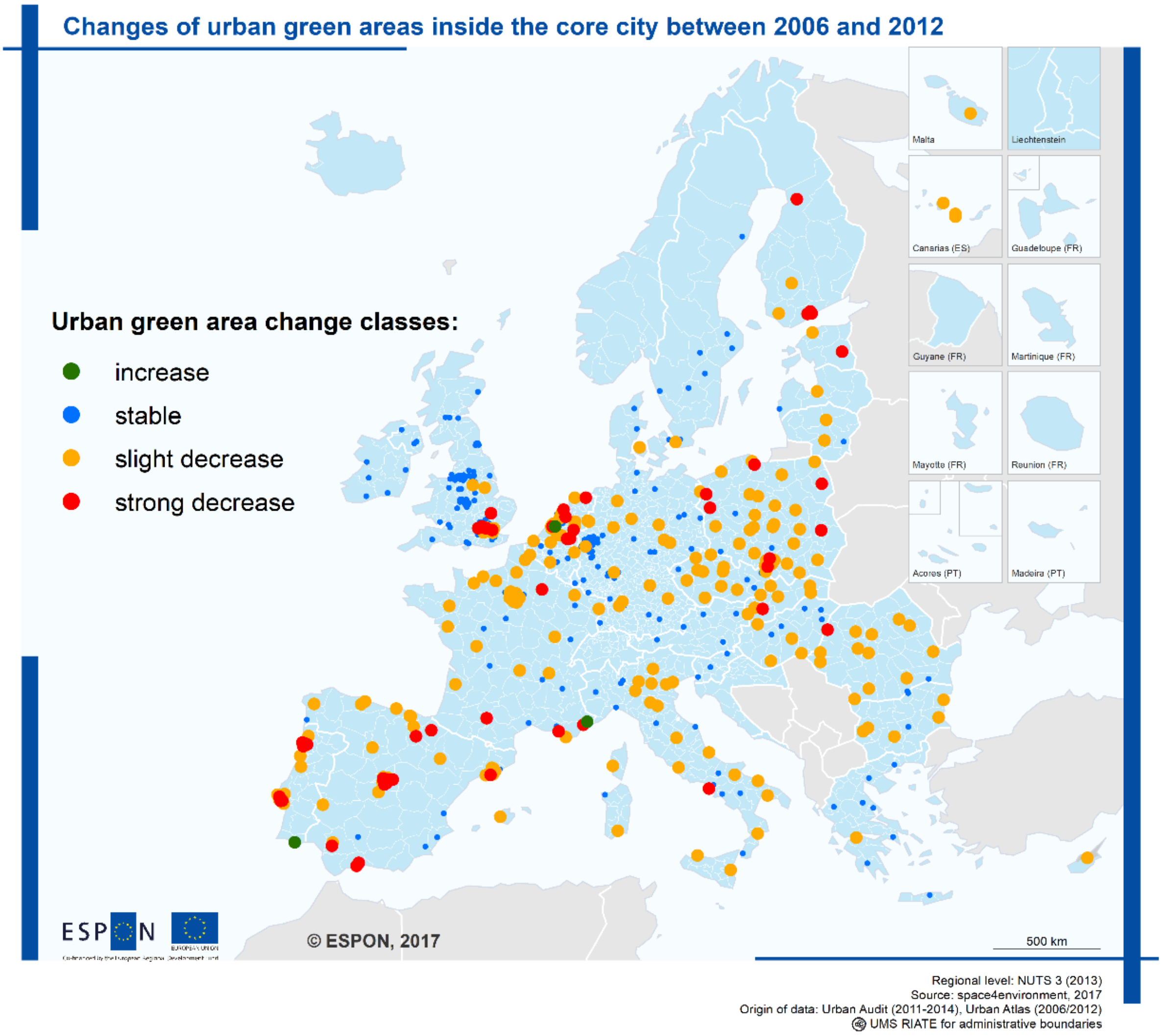
Map 5: Share of green urban areas inside the core city in 2012



3.6 How has urban GI changed between 2006 and 2012?

In the majority of European cities, green spaces have been either stable or decreasing between 2006 and 2012 (Map 6). While a stable situation is more prevailing in central and north-western Europe (in particular Belgium, Germany and the UK, but also the Alpine countries), a large proportion of decreasing green spaces can be observed in eastern and southern European countries, as well as in the Netherlands and Finland. In eastern and southern Europe, the most likely reasons for the decline are urbanisation processes due to economic development after the accession of the countries to the EU (eastern Europe) or for touristic purposes (southern Europe). Pamplona and Getafe in Spain are the two cities with the clearest decrease of urban green spaces, followed by CA de Sophia-Antipolis in France. Only three cities show an increase of urban green spaces, i.e. Faro (Portugal), Nice (France) and Capelle aan den Ijssel (the Netherlands). The fact that so few core cities in Europe have seen an increase in GI represents a critical opportunity for more joined-up, cross sector planning to reverse these trends, particularly in the face of the urgent need for climate change mitigation and adaptation action.

Map 6: Changes of urban green areas inside the core city between 2006 and 2012

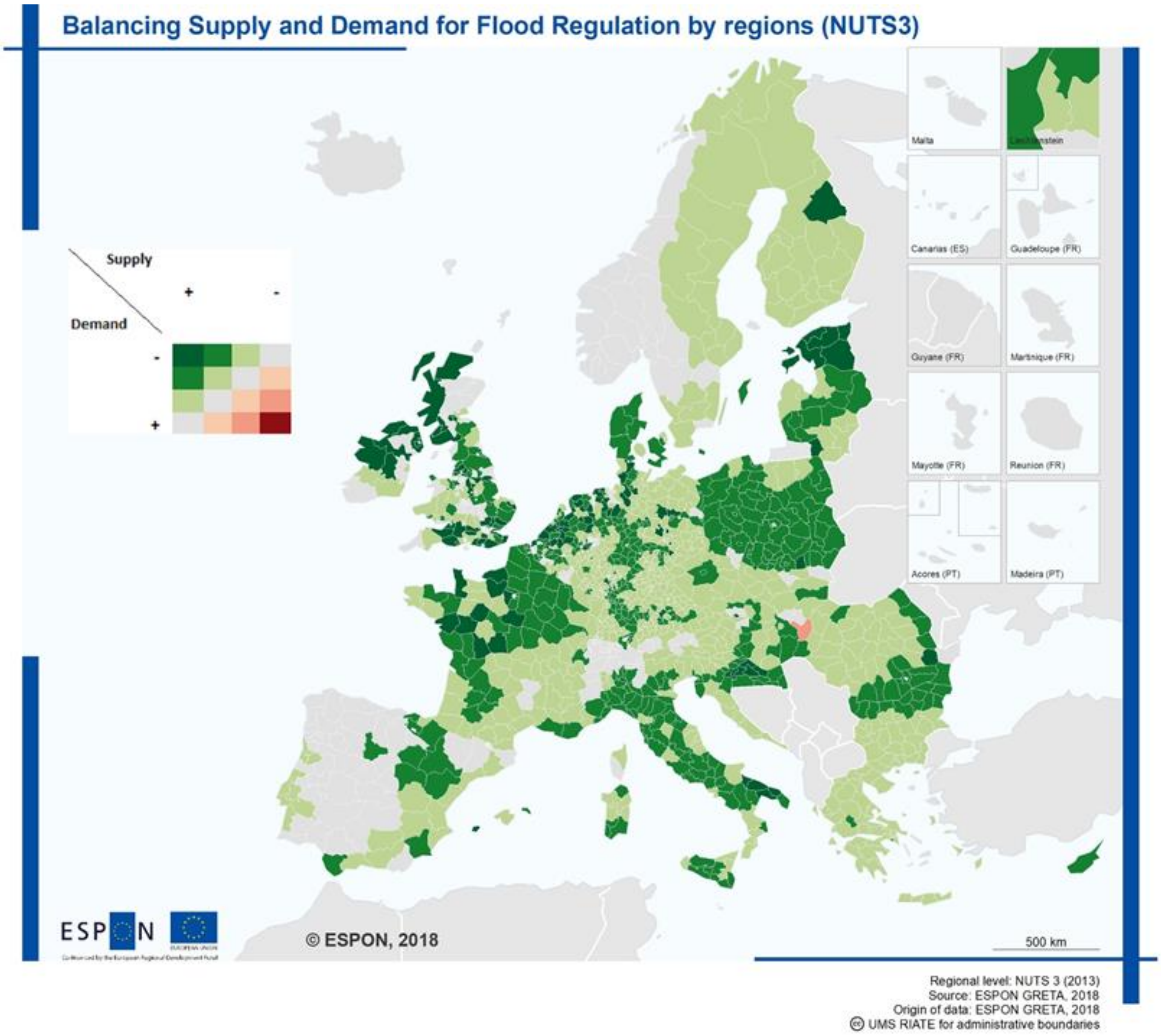


3.7 How do European regions fare in meeting existing demand for ecosystem services offered by GI?

The demand for ES can be defined as the amount of a service required or desired by society in a given location and time. This demand is directly influenced by a number of factors from the socio-ecological system and depends on factors like socio-economic conditions, cultural/behavioural norms, technological innovations, availability of alternatives, etc.

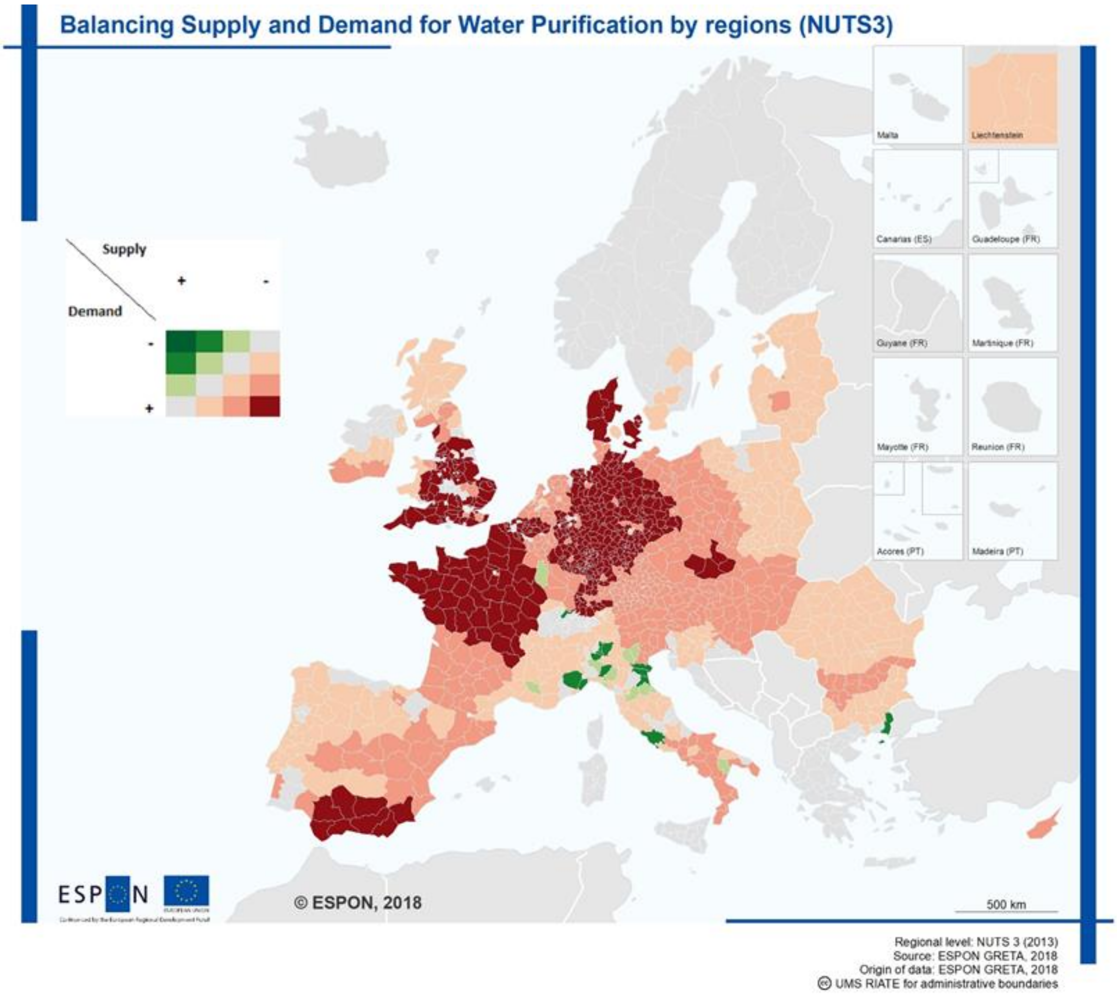
The following map shows the balance between supply and demand for flood regulation provided by regions, an ecosystem service that is very important for many people (see chapter 2). Maximum capacity of supply and demand can be found in few areas, mainly in northern parts of Europe. Other regions that are still green could be considered areas where the balance tends to be positive, in the sense that the supply is slightly higher than the demand. However, since the results are aggregated at regional level (NUTS3), most likely some areas within the region will not be balanced. Therefore, these regions should be considered with caution. Grey areas in the map would represent areas in balance, that are dominant in Spain, Southern Ireland, and parts of Scotland. Even if we consider these regions as “balanced”, there should be an element of caution since the degree of equilibrium could not precisely be measured. In practical terms it would mean that improving or reinforcing GI with the objective of water retention will have a substantial benefit in these regions. Finally, an extreme deficit (low supply with high demand) is only found in Hungary.

Map 7 Balancing Supply and Demand for Flood Regulation by regions (NUTS3)



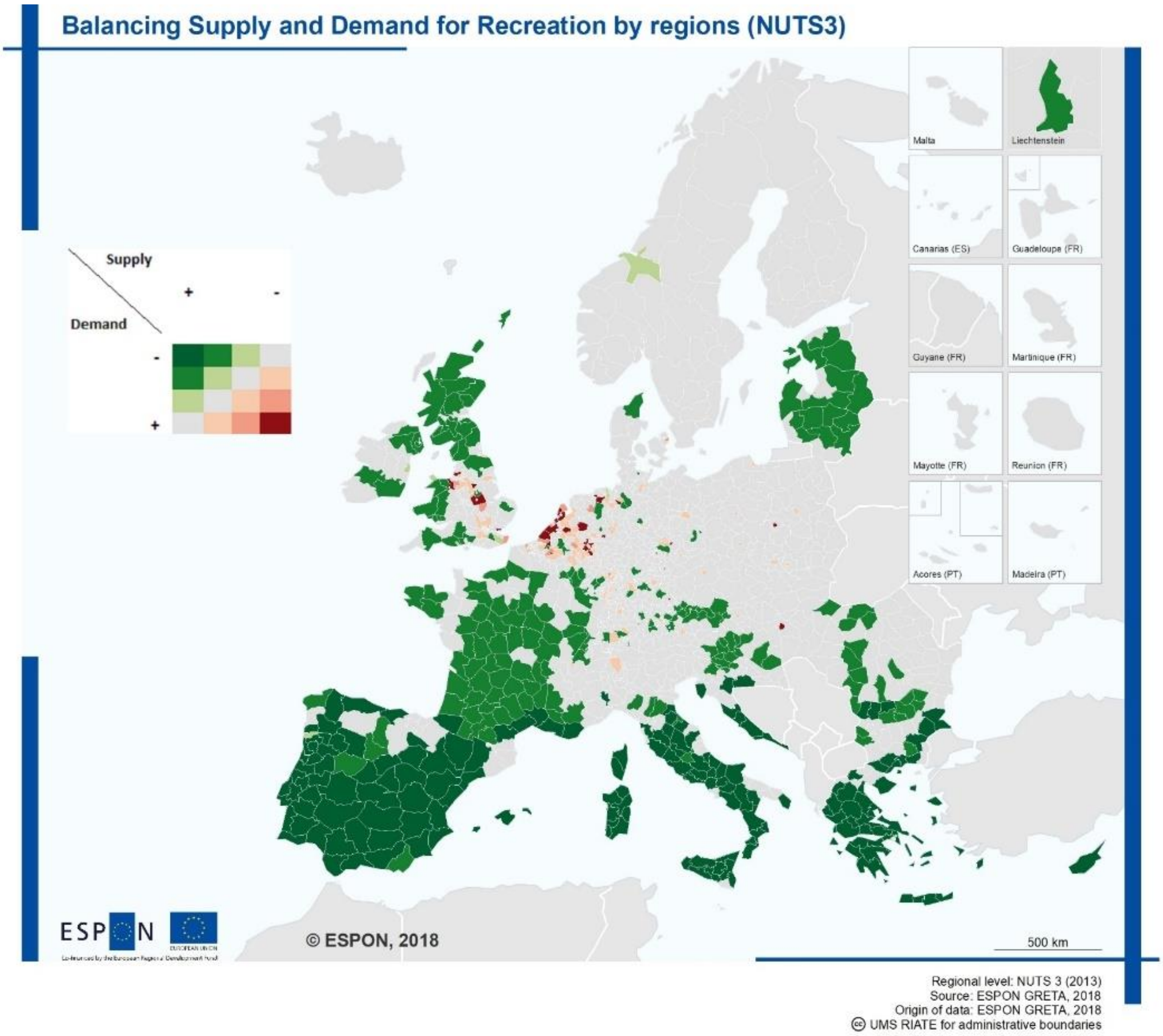
Water pollution is still a big challenge in Europe, as confirmed by most recent assessments. With few exceptions in Italy, substantial increase on the provision of water purification is still required.

Map 8 Balancing Supply and Demand for Water Purification by regions (NUTS3))



Recreation directly depends on environmental attributes like species richness, diversity of habitats, and climate. Map 9 shows a clear deficit of recreational services (low supply together with high demand) in the region known as the Manchester-Milan axes. It shows a discontinuous corridor spreading from the north of Wales, passing by Greater London, continuing to Paris metropolitan area and the Benelux states, following along south-western Germany, towards Northern Italy, to end in Barcelona. This shows a direct link with population density.

Map 7 Balancing Supply and Demand for Recreation by regions (NUTS3)



3.8 How do European regions fare in offering access to GI?

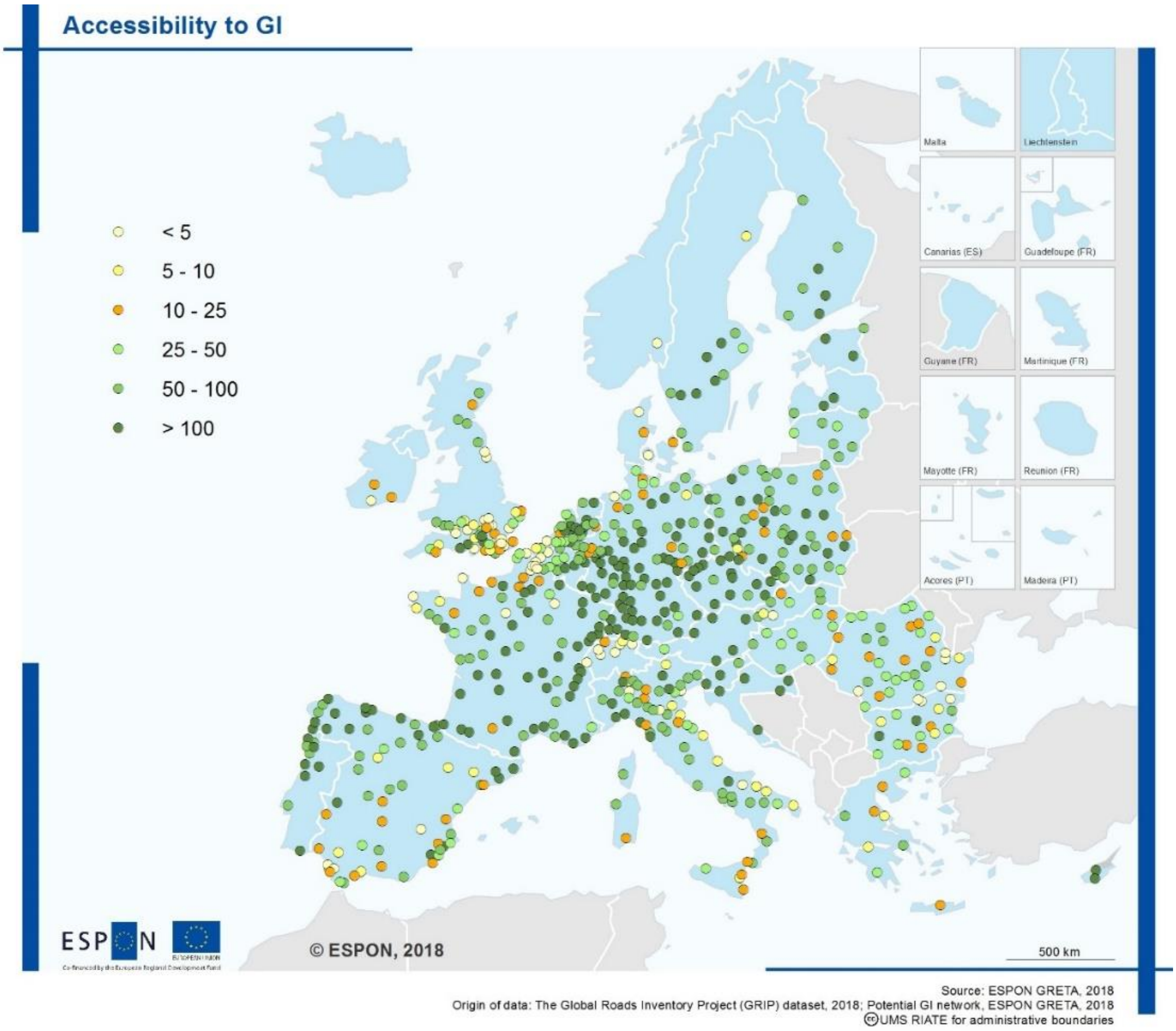
With the majority of people living in cities, urban green spaces are the primary source of contact with nature. Access to ES provided by urban green spaces is increasingly perceived as an important factor for quality of life. Moreover, the Sustainable Development Goals[8] set a specific target for public space (SDG 11.7): “by 2030, provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities”.

There is a substantial diversity in terms of accessibility to peri-urban areas, i.e. area of GI that can be reached within 30 minutes travel distance from the city centre. Cities with higher accessibility are scattered through Europe, although tend to be dominant in Sweden, Finland, the Baltic countries, Czech Republic, Austria, Germany and Portugal. Cities in Ireland, Denmark, and the UK are on the lower range of accessibility (less than 5 km^2). Differences in accessible GI depend on several factors as quantity of GI, its

[8] https://sustainabledevelopment.un.org/sdgs

distribution (concentrated, patchy, dispersed, etc), proximity to roads and trails, to name the most relevant ones. Therefore, available GI alone (or percentage of GI in the peri-urban area) does not ensure its accessibility. Accessibility depends on local conditions.

Map 80 Accessible GI in peri-urban areas. Area of GI, in km2, that can be reached within 30 minutes travel distance from the city centre



4. Supporting factors for European regions and cities in making full use of their GI and ecosystem services potential

According to a stakeholder survey conducted within the framework of the GRETA project, the biggest supporting factor in the process of implementing GI is a strategic vision that is shared by both, politicians and planners. Ideally, stakeholders involved in the GI implementation process agree on common goals and an integrated planning process, which ensures that planning, implementation and maintenance of GI are well coordinated. This requires that stakeholders dispose of sufficient knowledge of the cost-benefit ratio in employing nature-based solutions compared to the use of traditional grey techniques. Since GI has only recently been integrated in spatial planning, there is not a lot of long-term practical experience yet that could serve to systematically guide stakeholders through the planning, implementation and maintenance process of GI. Training measures could therefore be very helpful to enable planners and policy makers to fully tap the potential for GI development in their respective location. These measures should explain the functioning of ecosystems to stakeholders across different sectors, which is important because GI is a cross-sectoral concept. Furthermore, training measures should help raising stakeholders' awareness about the use of economic valuation methods of GI in planning and decision making.

Financial incentives and funding opportunities should ideally follow a functional approach that aims at preserving certain ecosystem services such as improving ecological resilience or increasing public health outcomes. The mere conservation of green areas is not sufficient.

One of the basic prerequisites for preserving and restoring networks of green and blue areas is to have geographical knowledge of the existing GI and its environmental qualities. While most European countries have information about the location of their protected areas readily available, georeferenced information on the environmental quality of these areas is not perceived as easily available on national levels. Continued mapping of land cover and land use patterns, (e.g. protected areas, forests, agriculture, level of fragmentation, ecological networks) and environmental quality of land and waters, is an important action for GI implementation. The available knowledge could be increasingly used as basis for decisions in spatial planning on where to locate new housing, commercial areas, industries, roads, waste disposals, which would enhance GI in Europe.

There is no general rule to who should lead the process of GI implementation. This largely depends on the existing policy or project targets, where the project is being developed and who is promoting it, whether it is a regional or national government, local municipalities, or the private sector. Ideally, it should be a cooperative process, in which local authorities are the main stakeholders but communities of interest and communities of practice are vital if GI is to be scaled out. Interdisciplinary teams guided by professionals should ensure the integration of knowledge from different domains. A combination of bottom-up and top-down approaches is probably the best option for effective GI implementation processes.

Case study: the green transformation of Cornwall and the Isles of Scilly

Cornwall Council adopted several strategies over the past years that should all lead the way for the region to transition to a green economy. In 2013, the Cornwall Council adopted a "Green Infrastructure Strategy for Cornwall". Together with the strategy on maritime resources that was adopted a year earlier, this strategy is important for the protection and economic development of the ecosystem services of the region.

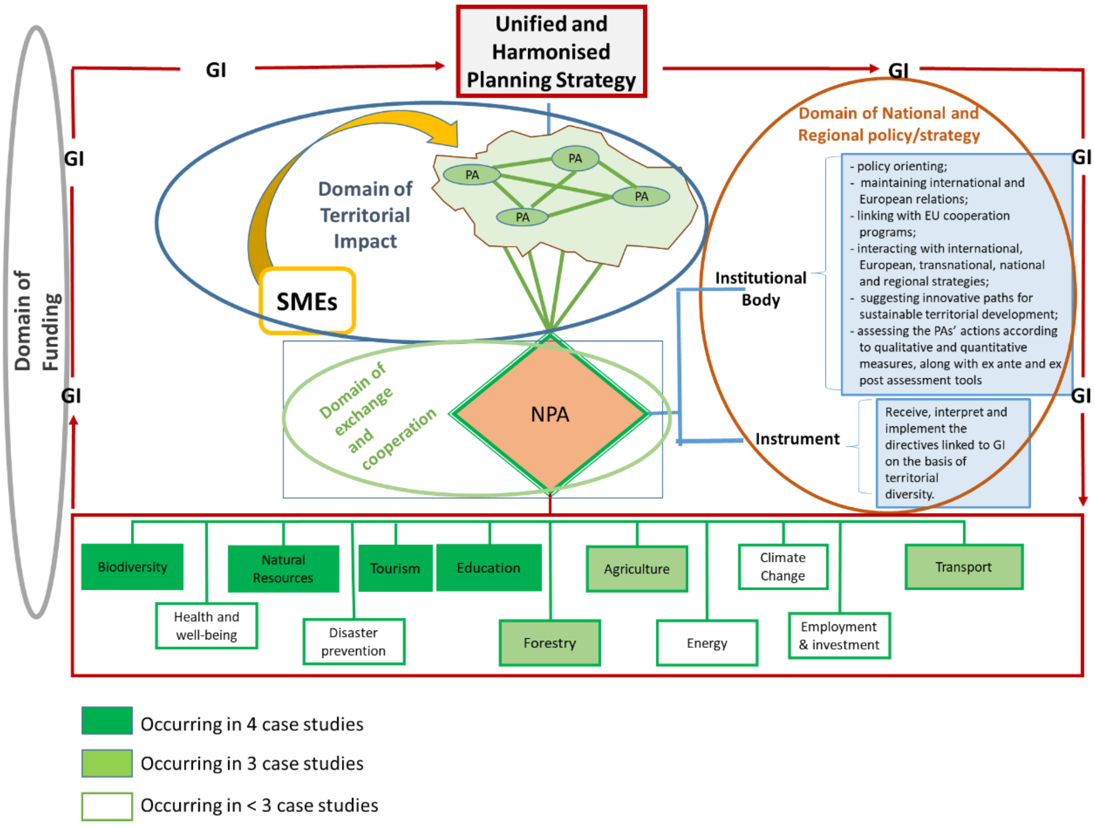
Traditionally the region has a high level of tourist attractiveness not least due to its beaches, landscapes and climate. The same properties of the natural ecosystems make the region also attractive for residents; but the low accessibility to diversified labour markets lowers the residential attractiveness. Therefore, a focus area for green transformation in the region concerns the integration of natural ecosystems' restoration in the planning of economic development and water basin management. The region's GI strategy aims, among others, at making the region even more environmentally attractive to tourists but also to residents. The enhancement of the region's natural assets is considered to have positive effects on different target groups: firstly, the GI strategy stresses the social inclusion effect of upgrading access to rich natural spaces from deprived areas, which are usually also the least environmentally attractive; secondly, an attractive living environment can be of importance for attracting the specialised labour force needed to work in the renewable energy industries, which are a focus of the region's economic development. In fact, the "Green Cornwall Strategy" is expected to create 10,000 jobs in maritime and geothermal energy industry and smart grid and electric vehicle solutions.

The local government works in partnership with related businesses and public research institutions, colleges and schools to generate a technological competence basis for this comprehensive development.

Source: GREECO, 2014

The relationship between GI, biodiversity and ES is dynamic and requires monitoring and examination over long time periods to develop effective and adaptive management measures. As highlighted earlier, the integration of GI principles in spatial planning and other sector policies is key in reaching wider territorial development goals. NPAs can play a pivotal role in this context, given that they are integral parts of GI networks. As suggested in figure 1, NPAs could be the focal point for GI implementation in the sense that they connect the relevant territories, the stakeholders concerned and the policy sectors. As such, NPAs could be both, institutional bodies and management instruments for the implementation of policies.

Figure 1: The role of NPAs in GI development



Source: LinkPAs project elaboration, 2018

However, until recently, protected areas and NPAs have played only a minor role and shown little interest in designing or implementing territorial policies targeting sectros other than biodiversity, natural resource management and few nature-dependant economic sectors. This is probably due to the lack of institutional capacities and significant decision-making power. Therefore, NPAs need to be equipped with adequate funding instruments, capacities and competences if they are to tap their full development potential.

In summary, the following factors are supportive for European regions and cities in making full use of their GI and ES potential:

- **Strategic planning is required to manage GI implementation and to maximise synergies and minimise trade-offs between different policy sectors.**
  Strategic GI planning aims to develop, conserve, restore or create networks of green (and blue) areas in order to provide environmental, economic and/or social benefits for urban and rural socities (at several institutional levels). In this context, it is important to understand the relationship between the supply of and the demand for GI in regions and cities. The GRETA type of analysis can help to inform the prioritisation of efforts to develop GI to meet current and future demand.
- **It is important to identify and quantify the main benefits and challenges of GI for strategic planning and development, irrelevant of scale of governance.**
  The existing data, information and knowledge about the multiple benefits and challenges associated with GI could be used more accurately to quantify the costs and benefits of implementing GI.

- **Spatial analysis of the relevant location (city, region, national scale) is key to identify the potential for GI networks, the hot spots, opportunities for investment in GI restoration and/or maintenance, etc.**
  The ESPON GRETA project produced relevant maps that can be used to inform strategic planning and decision-making in terms of land-use. The respective spatial analysis methodology can be downscaled for local level analyses, incorporating more detailed land cover, land-use, and ES data where available.

The following good practice examples can serve as inspiration for enhancing biodiversity and ES for territorial development:

- **Establish legitimising multi-level and functional governance structures that ensure GI implementation.**
  This entails, e.g. the creation of regional planning committees to show long-term political leadership for GI implementation; setting targets for public accessibility to outdoor recreation areas in spatial plans; establishment of cross-border cooperations and knowledge exchange to make full use of GI's potentials.

- **Use innovative policy solutions that ensure GI implementation.**
  Examples here include the use of a lottery grant to restore and enhance wetland environments; compensating private property owners for investing in water management, thereby decreasing flooding risks and the pollution of drinking water; developing regionally adapted methods to ensure integration of ES in spatial planning; the integration of a "green space factor" in planning and building practices, i.e. ensuring compensation of sealing measures.

- **Develop economic good practice to ensure GI implementation.**
  This includes the increase of water availability in cost-effective ways through rainwater harvesting, storm water management and greywater reuse systems; strict targets for climate-smart investments to ensure reaching the Paris agreement on climate change adaptation and mitigation.

- **Invest and support projects that enhance the quality of existing GI, or connect habitats and create new green areas to ensure GI implementation.**
  Good examples include the integration of GI for flexible and long-term sustainable use of a purpose built urban area; enhancement of the quality and quantitiy of green spaces through biodiversity plan with strict improvement targets; the use of strong visionary leadership to implement GI in times of sustainable urban transformation.

References

European Commission 2011, *Our life insurance, our natural capital: an EU biodiversity strategy to 2020.* https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0244&from=EN

European Environment Agency 2011, *Landscape fragmentation in Europe.* https://www.eea.europa.eu/publications/landscape-fragmentation-in-europe

European Commission 2013, *Green infrastructure (GI) – Enhancing Europe's Natural Capital*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0249&from=EN

ESPON 2014, *GREECO – Territorial potentials for a greener economy.* https://www.espon.eu/programme/projects/espon-2013/applied-research/greeco-territorial-potentials-greener-economy

European Commission 2016, *Mapping and Assessment of Ecosystems and their Services.* http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/102.pdf

European Commission/ Trinomics B.V. 2016, *Supporting the Implementation of Green Infrastructure.* Rotterdam

ESPON 2017, *ReSSI – Regional strategies for sustainable and inclusive territorial development: Regional Interplay and EU dialogue.* https://www.espon.eu/ressi

ESPON 2018, *Alps2050 – Common spatial perspectives for the Alpine Area. Towards a common vision.* https://www.espon.eu/Alps2050

ESPON 2018, *GRETA – GReen infrastructure: Enhancing biodiversity and ecosysTem services for territoriAl development.* https://www.espon.eu/green-infrastructure

ESPON 2018, *LinkPAs – Linking networks of protected areas to territorial development.* https://www.espon.eu/protected-areas

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