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The Green and Blue Network:

A spatial planning tool for sustainable development and a strategy for Climate Change Adaptation and Mitigation

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Abstract :

The Green and Blue Network (GBN) is a spatial planning tool used by the Metropolitan Area of Lyon, France and the Region of Hanover, Germany. According to the analysis of these two case studies, the GBN, along with a territorial governance scheme, has proved successful to achieve sustainable development and to become a strategy for climate change adaptation and mitigation. Although the planning systems of both case studies are different, they show comparable results on land-use protection (53% in Lyon and 43% in Hanover) for objectives such as biodiversity and natural resources conservation, carbon sequestration, natural risk management (floods, heatwaves and droughts), food security and human recreation. The success of this tool relies on the application of the concept of Green Infrastructure (GI). In both cases the principles of GI: spatial and ecological connectivity, multifunctionality and coordination with other policy sectors are clearly identified and become the drivers for the development of the strategies. Likewise, the concepts of ecosystem services and landscape functions play a key role in the aim of providing value to natural and green areas. Thus, this paper provides lessons on the GBN to encourage and guide its adoption and implementation worldwide.

Keywords :
Land-use / Green Infrastructure /Spatial planning
Landscape Functions /Ecosystem Services
Biodiversity /Climate Change /Sustainable development

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Introduction: Development and Environment

Motivation

Sustainable management of natural resources is key for the survival of humanity since our biological processes depend on them, however, economic pressures from an unsustainable development model have lead to their depletion and also to the deterioration of the natural ecosystems that ensure their provision. Currently, another important pressure has been added to the list; climate change, also caused by anthropogenic activities, exacerbates the impacts of natural disasters and reduces the resilience capacity of the ecosystems (eg: destruction of coral reefs by the bleaching effect leading to stronger floods and major damage in coastal areas). The type of pressures, though, vary according to the managed scale and the possible solutions need to be adjusted accordingly. For instance, at local scale, climate change increases the yield of runoff after heavier showers leading to more frequent discharges of untreated wastewater into aquatic ecosystems (Lennon, Scott and O'Neill, 2014). Likewise, at the regional scale, global warming increases the severity of summer or dry seasons, which leads to stresses on biodiversity. Thus, solutions need to comply to the characteristics of the scale and intervene in those ones that could otherwise worse the pressure. For example, the layout of a city that fosters impervious areas, impeding natural water infiltration, becomes a nested pressure on the runoff issue. At the regional scale, a land-use strategy that does not take into account the lack of open and vegetated corridors, blocking natural ventilation, worses the temperature rise issue. Thus, planning the territory aiming to protect ecological functions becomes a clear solution, one of many, for sustainable development as the two examples showed it. Steps on this endeavour are to recognize the value of natural areas, understand their pressures and current condition and seek for their protection against activities that are not compatible with their ecological function. These tasks are not easy to achieve for different reasons, one of them relates to the problem of becoming monetary a non-monetary item (Vierikko and Jari, 2016) and another one relates to the decisions made when securing the land for nature conservation (Fairheade, Leach & Schoones, 2012). At each scale of spatial planning, there is a vision for the development of the territory and thus, there are prioritized activities to carry out following the chosen land-use strategy. Since nature conservation, although fundamental for our survival, does not contribute as much to the economic growth of a nation or a city as other policy sectors do, when the weighing of the contributions is based only on monetary terms, the protection and restoration of natural areas have not been the classic driver for

development and policy making but rather the rare one. Thus, the need to find a balance between policy sectors and provide the adequate value to nature have been a major issue for decades. Fortunately, a promising concept to tackle this issue, acknowledged as early as the 2000s (Naumann et al., 2011) (Benedict and McMahon, 2001), is finally getting off the ground: Green Infrastructure, GI, a concept that by definition recognizes the value of blue and green areas at all scales and aims for their adequate management. Yet, the implementation of GI in the last two decades has been rather slow and supporting policies to speed up the process are needed (Roe and Mell 2012). The use of spatial planning (an scheme of practices and policies that influence the distribution of activities in space and determine the use of land) provides a clear opportunity for it. However, worldwide, economic interests and an increasing population are strong pressures for the use of land, hence, environmental and spatial planners deal with the crucial task to identify the natural areas to be protected and restored at different scales, and to propose strategies that secure their ecological functions. Additionally, the concept of GI brings within other term: ecosystem services, ES. Although, this term is still on a phase of development from the theory to the practice, currently, evolved environmental planning ideas from the 1970s have joined this concept (Von Haaren & Albert, 2011) aiming to enable a conversation between policy makers and scientists, support the concept of ecological functions and to reduce the gap between theory and practice.

Methodology

From such proposed strategies, the green and blue network, is highlighted and currently adopted by european cities at the regional or metropolitan scale. The up-to-date state of the discussion and the degree of the GI implementation at regional and local levels is being addressed by the European Commission in the last two years (Maes et al., 2019). In this way, this research intends to provide useful and additional information to that discussion and join the endeavour of proposing policies that help to advance the implementation of GI. The mean to do so, is the assessment of two case studies, two frontrunner cities on this context, that have developed a clear GI strategy at the regional and metropolitan scale: Lyon in France and Hannover in Germany. The evaluation of these schemes will be methodized in three segments: 1-Policies and regulations, 2- Prioritization using funding allocation, 3- Sectoral policies coordination and coherence with other environmental endeavors such as climate change adaptation and mitigation. The lessons drawn from this research will become a guide for cities on other regions of the globe such as Latin America where these strategies will be beneficial and where some cities are just starting to adopt this regional approach. The

question to be address along the document is if the green and blue network, GBN, as a spatial planning tool helps to achieve sustainable development; this one, understood as a development that ensures the provision of ecosystem services, thus ensure nature protection, and a development that aims to act on climate change adaptation and mitigation.

Structure

The organization follows a structure of 4 chapters. Chapter 1, builds the framework for green infrastructure, ecosystem services, synergies, trade offs, pressures and conditions of ecosystem services and landscape functions. The chapter also provides explanation of the basic concepts required to do an evaluation and comparison of two case studies given a set of criteria (chapter 3), as well as an explanation of climate change as an element of pressure and its relation to spatial planning and policy sectors.

In chapter 2, the introduction of two case studies is carried out. In this chapter the GI strategies are described and the implementation obstacles are highlighted. Likewise, in chapter, the case studies are compared and assessed based on the following criteria, and the results of this comparison and evaluation are discussed:

- Green and Blue Network Driver
- Green and Blue Network Purpose
- Influence of Green and Blue Network from regional to local scale
- Regulations from the implementation of the Green and Blue Network strategy
- Application of Green Infrastructure
    - Connectivity
    - Multifunctionality
    - Coordination with sectoral policies
- Monitoring scheme
- Community participation
- Funding schemes for implementation of the Green and Blue Network
- Other outcomes

The analysis includes the information gathered from the interviews performed to the following professionals and analyzed data from the literature reviewed:

1. Dr. Wolfgang Jung: The director of regional planning in Hanover, Germany.
2. Dipl.-Ing. Heike Grebe: Member of the regional planning in Hannover, Germany a GIS expert.

3. Dipl.-Ing. Martina Schunke: Member of the environment and Urban Green department for the capital City of Hanover, Germany.
4. Philippe MARY: Responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, France at UrbaLyon.

Chapter 4 is dedicated to draw on conclusions and recommendations for further implementation of this strategies in other functional areas worldwide.

Chapter 1: Green Infrastructure, sectoral policies, spatial planning and climate change

The first chapter provides useful information on green infrastructure, climate change as an element of pressure for other sectoral policy objectives and spatial planning; concepts required to analyze the two case studies.

1.1 Green Infrastructure: "The Green and Blue network"

1.1.1 Concept

The concept of green infrastructure, GI, albeit used for more than two decades, (Naumann et al., 2011) (Sussams et al., 2015) and with roots placed in the planning and nature conservation efforts of the 19th century (Grădinaru, 2018) still lacks of clarity and of a worldwide common definition. As a result, it remains to be one of the main problems encountered in the implementation of nature-based approaches into spatial planning and could compromise the ability of GI to assist sectoral policies objectives and to contribute to sustainable development (Mazza et al., 2011) (Sussams et al., 2015) (Reckien et al., 2018) (GRETA, 2019). Currently, the environment protection agency EPA of the united states and the European Commission, EC, state their own concept of GI. The EPA defines GI as way to manage wet weather impacts while providing community benefits. In the case of Europe, in 2011, the proposed concept for GI included keywords such as network, ecosystem health, ecosystem services, and biodiversity conservation (Naumann et al, 2011). Two main differences between those definitions is, in the european one, the introduction of the concept of ecosystem services, ES, and the extension of its application to other policy sectors further than water management. From 2011 the concept has evolved in order to solve the obstacles and facilitate its implementation. As explained later in this document, the use of ES within the definition of GI is key to build connections with other sectoral policies and could be a path to connect to spatial planning. Although the concept developed in 2011 certainly explains what GI can do in terms of ES provision and enhancement of ecosystem resilience, it does not provide a clear connection to Spatial Planning (Mazza et al., 2011), which plays a key role ensuring the balance between developed areas and open spaces and, through regulations, "defines the quality standards of the living space for both people and nature" (Golab-Korzeniowska, 2019). Thus, this definition led to the misperception that GI was limited to be a biodiversity conservation initiative (GRETA, 2019). The aim to broad this

notion and promote GI as a spatial planning tool used to accomplish targets from sectoral policies, made the European Commission to communicate in 2013 a new definition more compact and clearer for GI practitioners. The different emphasis on the aforementioned definitions may suggest that the concept is still under construction (Sussams et al., 2015) and thus, the importance to clarify that the definition used on this document is the following:

> "Green Infrastructure is 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" (EC, 2013).

This definition is the most comprehensive one and the one used in the most recent GI analysis reports up to 2019 in Europe such as GRETA and ENROUTE. Through this definition, the concept of GI principles can be introduced.

1.1.2 Principles

The GI definition expresses two important principles for its integration into spatial planning, connectivity and multifunctionality:

1. **Connectivity:** as result of strategic planning, this aspect of GI means an intended network of green spaces of ecological importance called hubs (in Europe, comprised mainly by protected sites such as Natura 2000 and Emerald sites) connected by links (non-protected natural and semi-natural areas) at an urban, regional and national level (GRETA, 2019). Those links are also called corridors which seek for ecological continuity (Mitroi et al, 2014) and the delivery of ES. Connectivity is expressed as structural and functional connectivity, for animals and plants and also functional connectivity for humans. It is important not just to connect habitats but confirm that the connection provides the intended service.

2. **Multifunctionality:** This aspect challenges the single purpose approach of grey infrastructure with "the idea of the same geographical area being used for several purposes/activities and, at the same time, also supplying multiple ES" (GRETA, 2019). Indeed, GI could be a substitute in certain situations and should always be a complementary solution for grey infrastructure. For

instance, the flood management strategy in Nummela, Finland, showed that restoring a wetland is more sustainable and cost effective than unnatural solutions when managing surface runoff; with the plus of having at the same time recreational and wildlife benefits. The numbers were €62 000/ ha of wetland restored while man-made solutions costs €50 000 per 100 metres (Naumann et al, 2011b). This difference in costs becomes even more relevant in countries of the global south where promoting GI is more economic-wise than trying to finance expensive traditional engineering solutions since the technology in these countries is not as advanced. Thus, as explained the previous example, multifunctionality is the capacity to provide social, ecological, economic and cultural functions (Grădinaru, 2018). This principle can be also communicated using ES and perhaps confused with the following principle, coordination, but as it will be seen in the following chapters the concept of landscape functions and ES allow to understand the difference. The land-use does not need to be only one, it could be multiple uses and those uses or functionalities can be guided by objectives from different sectoral policies.

These two principles guide the strategic plans of some European cities (Grădinaru, 2018) along with coordination, multi-scale (Niedźwiecka-Filipiak et al., 2019), and identity. The importance of these principles is that they should be represented by the ordinances described in the planning documents. A clear set of principles ensure that the decisions made are coherent and convey the essence of green infrastructure and the delivery of its benefits.

3. **Coordination:** it is a principle that evoques the relationship of GI with objectives from sectoral policies or other planning domains such as water management. To evidence this, the strategy analyzed in this study: the green and blue network supports objectives from the climate change sector by increasing carbon sequestration through an increment of forested area in the corridors/links connecting hubs at the regional level. It also supports the water management sector by daylighting creeks, protecting floodplains and restoring riverine zones through the blue corridors. Likewise, it supports biodiversity conservation by allowing migration of fauna in between cores and by ensuring food security through agricultural lands protection. Finally, it supports the human health policies by encouraging people to do hikes and

keep themselves in contact with nature which has been shown of great importance for human mental health (GRETA, 2019) (Wiesztort, 2015). The connection between policies and GI is understood through the provision of ES at the european level, however at the regional and local level this concept is not well introduced and barely implemented as it will be analyzed in the following chapters.

4. The principle of **multi-scale**: it is first understood as the spatial planning level at which GI has been implemented, being national to neighbourhood level the range and the ideal scope. In this document, the scale to be assessed is the metropolitan scale.

5. **Identity:** it sees GI planning as a means to build the sense of place (Grădinaru, 2018). This principle is highlighted in the case of Lyon, where the citizens' demand for green and leisure areas have an important role on what supports life quality for them (Wiesztort, 2015).

1.1.3 Typology

Giving continuity to the definition of GI, it is important to also understand the topology of GI. The different types of GI are used in the spatial planning network proposed in the case studies. From the final report "Green Infrastructure implementation and efficiency" wrote by the institute for European environmental policy (Mazza et al., 2011) and the report "Green infrastructure: Enhancing biodiversity and ecosystem services for territorial development (GRETA, 2019), the typology used for GI elements consists in 6 types showed in graph 1.

1.2 Ecosystem services

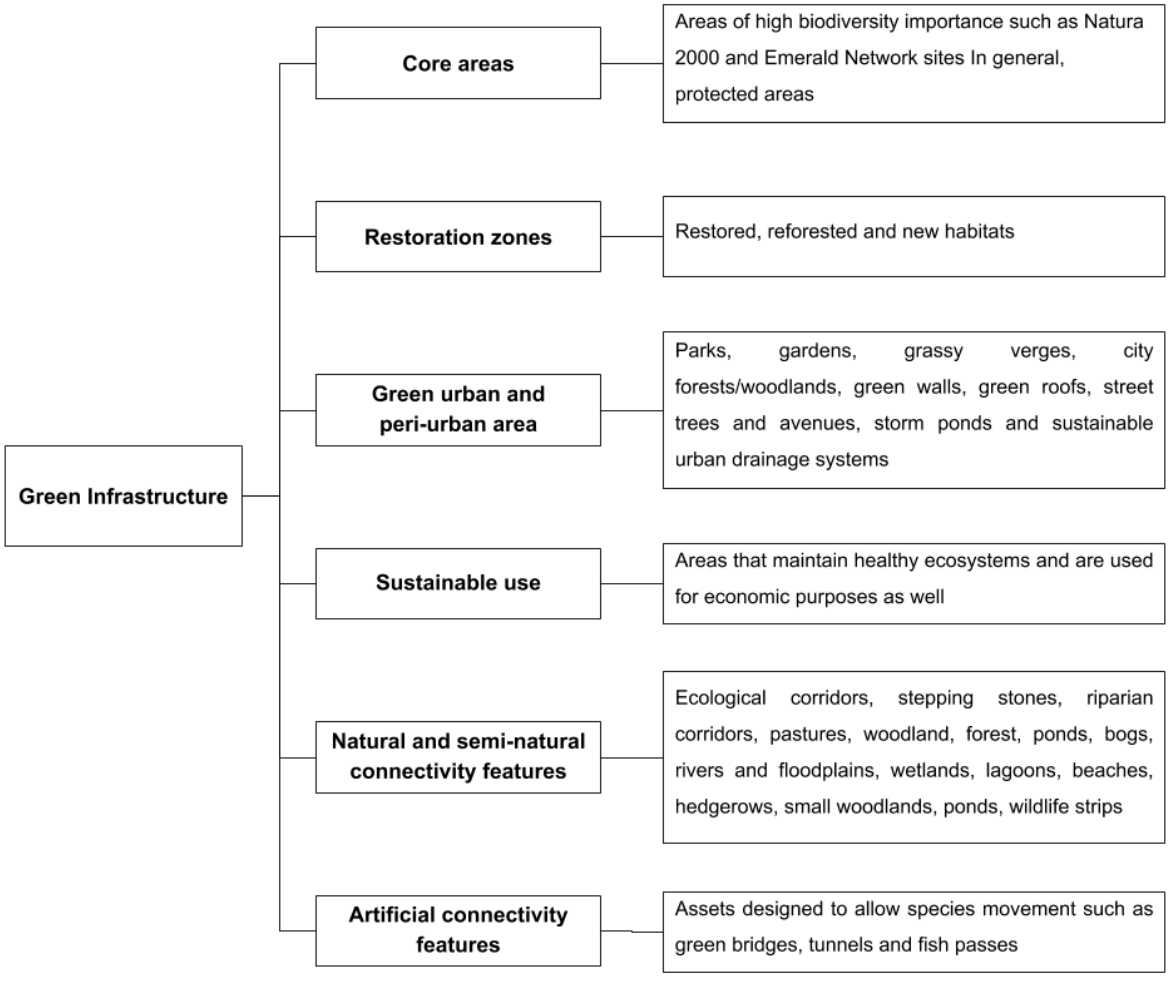
This section has the intention to introduce the concepts of ecosystems and ecosystem services which are widely used by the reports of the European Commision to reveal the importance of GI in spatial planning.

1.2.1 Ecosystems

According to the GI definition, the benefits from the implementation of GI come from the capacity of different ecosystems to provide multiple services. As GI is classified in six different types (see graph 1), ecosystems are also classified in different categories. Graph 2 shows the classification for twelve different ecosystem types. The main three ecosystems

are terrestrial, freshwater and the marine environment (MAES, 2013). It is important to clarify that cities as built environments are also recognized as an ecosystem and that within the urban area or urban ecosystem different types of green infrastructure can be identified (MAES, 2016):

> "urban ecosystems are cities, socio-ecological systems where most people live. Just as other ecosystems, they are characterised by the interactions of energy, matter or information between and within their functional components. Urban ecosystems consist of green infrastructure and built infrastructure" (Idem).



Graph 1. Green Infrastructure typology. Adapted from GRETA, 2019.

In fact, cities play an important role in supporting biodiversity; stats from the Natura 2000 network which currently covers 18% of EU territory and becomes the backbone of Europe's GI (Sussams et al., 2015) show that 9, 878 out of 27, 308 sites of this network are at least partially within the functional urban areas (FUAs) (MAES, 2016). Understanding FUA as the

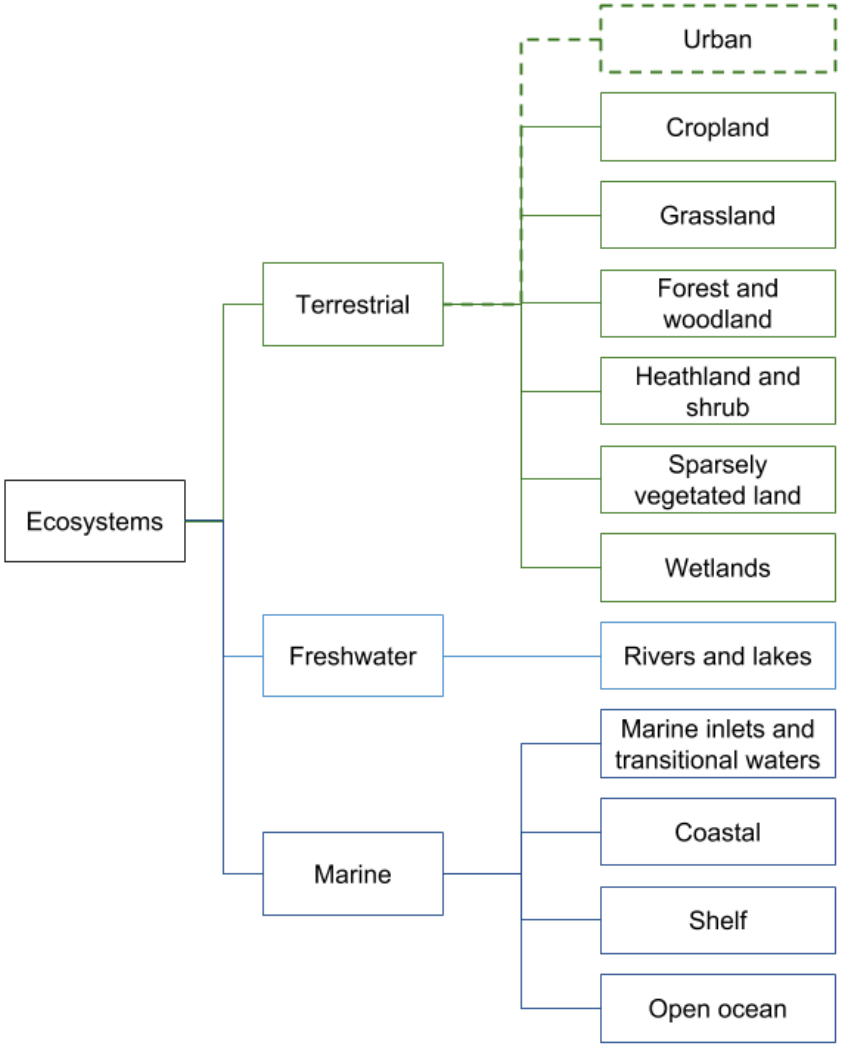
urban and the respective peri-urban area or as:

> “a territorial unit resulting from the organisation of social and economic relations within that. Its boundaries do not reflect geographical particularities or historical events. It is thus a functional sub-division of territories”, (GRETA, 2019)

Thus, the high importance of cities and their GI strategies to mitigate and adapt to climate change and to support other sectoral policies such as water management (Sussams et al., 2015) becomes clearer.

1.2.2 Ecosystems services

After introducing the concept of ecosystems, it is possible to explain their services. ES are the benefits of GI and they depend on the good condition of each of the ecosystems described above: “healthy ecosystems are the fundamental basis for a resilient society and a sustainable economy” (Maes et al., 2018). Additionally, since ecosystems are identified at different scales, it is important to made an analysis of ES with a wide spectrum of scales, especially at the local and regional scale where the importance of “bypassing typical distinctions, such as ‘urban’ or ‘rural’“ (Sussams et al., 2015) due to the influence of one into the other through the principle of connectivity is more relevant. Thus, this analysis provides a long list, all in all, mother nature is complex and its services to our human species are endless. Thus, an analysis of all the ecosystem services from each of the ecosystem categories in one single chart may be overwhelming, not practical and might create an obstacle for a wider understanding. A simpler and general classification between urban ES and landscape ES in relation to seven sectors for GI application, is shown in graph 3 (GRETA, 2019) (Mazza et al., 2011). The result of this distinction, although not exhaustive, is a complete and less complex set of ecosystem services that can be presented to and understood by policy makers and practitioners.



Graph 2. Ecosystems typology including class 1 and class 2. Adapted from MAES, 2013.

More exhaustive charts of ES can be found at the MAES reports, they include a set of ES for each type of ecosystem (MAES, 2013). However, the intention of this chapter is to set common ground on the basic concepts such as ecosystems, ES, GI, pressures and conditions of ecosystems and focus the research on green and blue network strategies, GBN at the regional and local scale. Hence, Graph 3, adapted from table 1 of the GRETA report, aims to unify different concepts from the literature and provide a classification of ES highlighting their character as provisioning, regulating and maintenance or cultural services. This graph also allows to understand the principle of multifunctionality, described in the previous section, by showing direct positive economic impact to society and to the well-being of humans through some ES. These three groups of services correspond to the Common International Classification of Ecosystem Services (CICES v4.3): 1- The provisioning service comprises tangible things that can be traded or exchanged, consumed or used by people in the industry. 2- The regulating and maintenance service includes all ways in which

ecosystems control or modify the environment of people such as pollution regulation, climate regulation, water flows regulation and nutrient cycling. 3- The cultural services consist of the physical, intellectual, spiritual and symbolic interactions with ecosystems (MAES, 2013). The seven sectors depicted in graph 3, along with the recognition of economic and health impact of some ES, facilitate the recognition of the relationship between ES, GI and policy sectors such as biodiversity, disaster risk reduction, ecosystems-based approaches, water management, urban, transport, health, and economy, among others.

Although graphs 2 and 3 provide information that helps to clarify the concepts of ecosystems and ES, the gap between theory and practice still exists. The implementation of GI by urban planners in the strategic plans does not necessarily imply that the ES concept is being used to facilitate conversations and negotiations when deciding land-use. This gap is evidenced when analyzing the reports of the european commission explaining the theory of ES and displaying maps of ES potential for implementation at the european level and the planning documents at regional and local scales. This issue is acknowledged by the european commission and in the attempt to close the gap, it has launched the pilot project ENROUTE that introduces the model of city-labs during the period of 2017 and 2018 but is limited to only 18 cities in Europe (Maes, 2019). So, as a contribution on this discussion, the inquiry of how the ES concept has percolated the spatial planning system is addressed in this research using the two case of studies (see chapter 2).

1.2.3 Synergies and tradeoffs of ecosystem services in spatial planning

After analyzing all the ES, it is common to assumed that the implementation of GI will pursue the maximisation of all the potential benefits, however, this belief is unlikely due to the concept of synergies and tradeoffs of ES: “Associations among ES are understood to occur when multiple services respond to the same driver of change or ecological process, or when interactions among the services themselves cause changes in one service to alter the provision of another” (Idem). Analysis on trade offs and synergies is still a new concept and different approaches can be found in the literature. For instance, an spatial analysis made in Detroit to determine most suitable locations for GI implementation led to different results when maximizing stormwater management objectives in contrast with increasing landscape connectivity objectives. The reason of this discrepancy is the information and indicators used to generate the maps for each objective. In the case of stormwater, areas highly urbanized provide higher runoff coefficients whereas landscape connectivity was more important in areas where the land cover was classified as forest since this type of land cover was considered as a provider of habitat for a largest number for species. Thus, highly urbanized

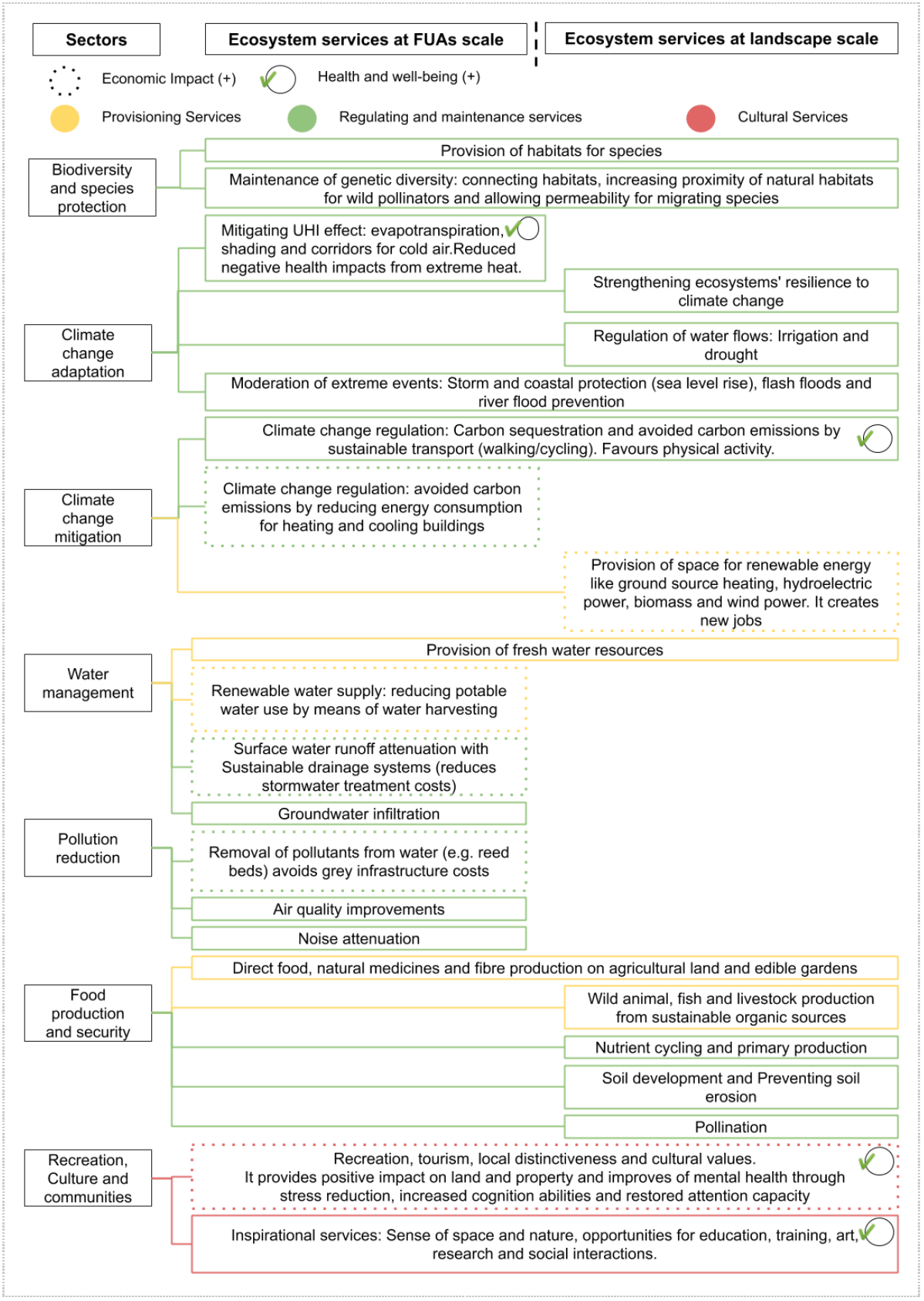
areas did not match with areas where natural ecosystems were more abundant although fragmented (Meerow, and Newell, 2017). Likewise, a study on Portugal showed how spatial planning for multifunctionality delivers different results for priority areas when local temperature regulations is favored than when population proximity to public green spaces is preferred. This disparity confirms once again the existence of tradeoffs among ES and the challenge of the principle of multifunctionality (GRETA, 2019).

In addition to the previous approach, an analysis of selected ES serving the same policy domain like climate change, biodiversity or water management shows other tradeoffs and synergies. For example, under the climate change sector, ecosystem services such as gross nutrient balance and net ecosystem productivity showed negative relationship since the later benefit increases the accumulation of some nutrients through the fertilizer effect (Idem).

1.2.4 Condition and pressures of ecosystems

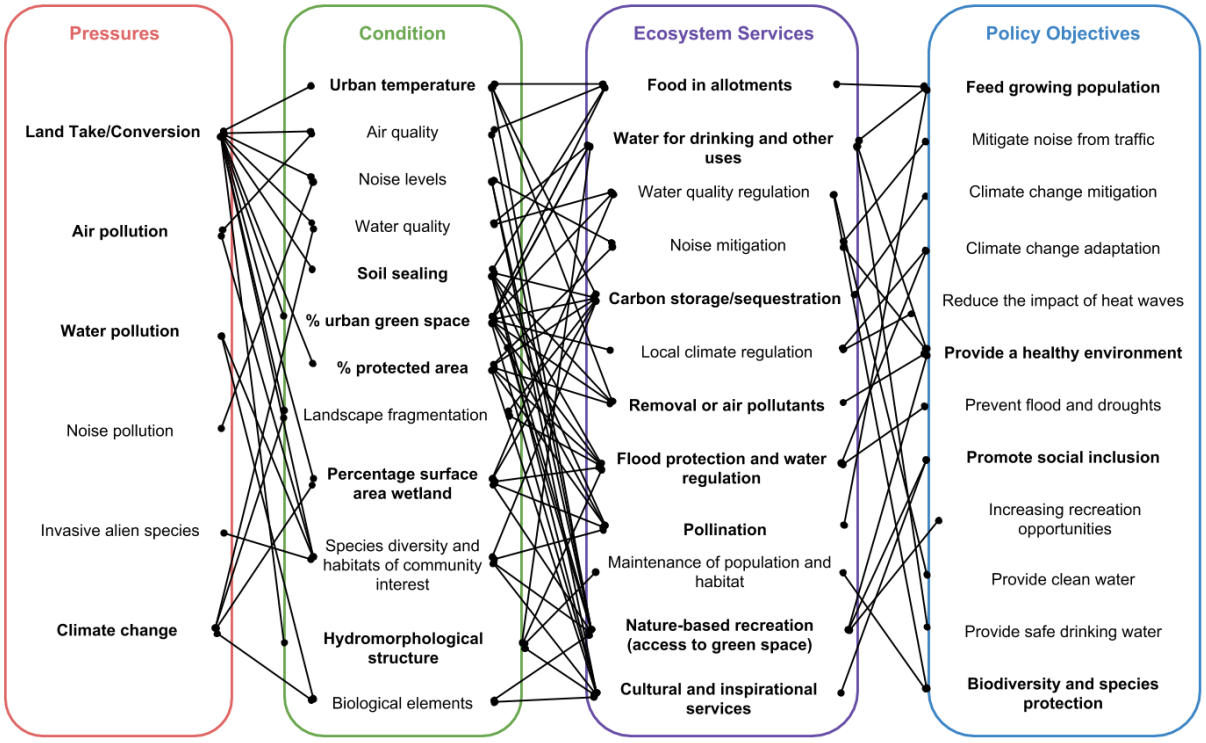
After understanding the ES and their synergies and tradeoffs, it is also important to understand the conditions required to deliver those ES and the pressures over the ecosystems that affect their capacity to deliver the ES. As stated before, the capacity of an ecosystem to deliver ES depends on its good condition, which is understood as "the physical, chemical and biological condition of an ecosystem at a particular point in time" (Maes et al., 2018) with the purpose of providing a service. Thus, GBN strategies, which are based on the GI definition, should take into account the variables to be monitored or targeted for restoration purposes with the final goal of providing the corresponding ES. A proposal for a set of ecosystem condition indicators based on a reference of the condition in 2010 is explained in the fifth MAES report. This proposal aims to improve the baseline conditions of 2010, which keeps into account the current pattern of land cover, land use and management.

Similarly, a set of indicators for the pressures that influence the ecosystems condition are introduced in the same report. The importance of monitoring the pressures relies on the possibility to disclose the reasons of the environmental degradation and thus the detriment of the ecosystem condition. The relationship between pressures and ecosystems condition might not be seen immediately due to a delayed response or change in the ecosystem.



Graph 3. Ecosystems services at FUAs and Landscape scale. Adapted from GRETA, 2019.

An example could be seen with the pressure of nitrogen deposited on a forest during a year (measured as kg N/ha/year) and the response of a lake on the level of pollution (indicated by the concentration of nitrogen in a volume of water, N mg/l). The pressure of nitrogen in the forest could have started long time ago before the lake's degradation is noticed, thus, measuring both indicators help to understand the connection and do prevention (idem). The acknowledgement of these relationships helps policymakers to develop policies that reduce the pressure and ensures the capacity of an ecosystem to deliver its service. An important highlight of identifying these relationships is the recognition of climate change as an element of pressure as seen in graph 4, which diminishes its importance in the endeavour of maintaining a good ecosystem condition.



Graph 4. Relationships between pressures, conditions, ecosystem services and policy objectives for a green and blue corridor, usually part of a GBN strategy, which includes three types of ecosystems: wetland, freshwater and urban ecosystems. Adapted from MAES 5th report (Maes et al., 2018).

Although ecosystems are analyzed separately, the exercise allows to visualize the multiple and stronger connections for a natural element within the urban area. Land-take and climate change are important pressures to be addressed. Spatial planning in this case play an important role on securing the land and including climate change impacts and objectives of the policy sector into the planning system.

1.3 Sectoral policies and climate change

1.3.1 Sectoral policies

Giving continuity to the principles of green infrastructure and to introduce climate change and sectoral policies, a statement from the EU report on the implementation of the EU strategy on adaptation to climate change (EU, 2018) recommends for the european climate change adaptation strategy using GI that:

> "Multi-functionality should be better embedded in the assessment of adaptation options. This would allow nature-based adaptation solutions to compete in the short-term with other, more conventional or 'grey' infrastructure options"

Indeed, the multifunctionality principle of GI as a tool for climate change is not yet widely considered in several european cities. "The concept of multifunctionality in GI planning means that multiple ecological, social, and also economic functions shall be explicitly considered instead of being a product of chance" (GRETA, 2019) and this can be achieved through the integration of policy objectives into GI planning and implementation. Deepening on the relationships of GI and sectoral policies, the clearest connection comes from the sectors of water management and biodiversity protection. In the european case, through the regulations of the water framework, nature-based solutions are introduced to restore the ecological condition of water masses to a good status and ordinances from the water management sector become direct input of the spatial planning strategies analyzed in this research as seen in chapter 2. Likewise, biodiversity through the program of Natura 2000 have being a driver for GI implementation. Moreover, green infrastructure, through the concept of ES, has also application in other policies such as climate change, disasters mitigation, and health and well-being (Szulczewska, Giedych, & Maksymiuk, 2017) as shown in graph 3. The GRETA report (2019) shows that GI has been implemented into water management, agriculture, climate change, environmental protection and biodiversity conservation more than in sectors such as finance, energy, and social services. Yet, on the analysis of these connections, it is important to recognize climate change as an element of pressure and its influence on other policy objectives. According to the study: How are cities planning to respond to climate change?, climate policy is not the main targeted objective in european cities, being the 5th on a list were biodiversity conservation was on top, followed by human health, sustainable land management and water management (Reckien et al., 2018). Biodiversity has one of the clearest connections with climate change; in this case, the loss of biodiversity is the result of impacts on species and their habitats. Water management is another policy closely related to climate change. Flooding and drought prevention are part

of the objectives of this policy and these environmental issues are to be exacerbated by climate change. Health and well-being is another sector that shows a relationship between climate change and air pollution. The exacerbated effects of low air quality under stronger heat waves increases the vulnerability of the human population. Also, respiratory illnesses, due to worsen effects of air quality, impact the economy because the higher investments in health (Naumann et al, 2011b). These examples show the connection of climate change to sectoral policies. So, if global warming stresses the ecosystems by, for example, reducing soil moisture, initiatives promoting the hydrological cycle should be highlighted and indicators on this matter should be considered under the climate change policy (Climate-Adapt) and vice versa for other sectoral policies, where objectives related to climate change should be stated. As a conclusion, two problems are described: 1- the need to connect the concept of ES of GI with sectoral policies and 2-prioritize climate policies since it influences other policy objectives.

1.3.2 Climate change and sustainable cities

Since 1988 the international panel on climate change (IPCC) has been providing policy makers with scientific data regarding global warming. As a response global agreements such as the Earth summit in Rio in 1992, the kyoto protocol in 1997, the Copenhagen accord in 2009 and the latest the Paris agreement in 2015, have been held with the purpose of setting up environmental targets as the one limiting the global temperature rise to 1,5 celsius degrees above pre-industrial levels. However, despite the staggering numbers from the last report (concentration of carbon dioxide in the atmosphere is higher than 400 parts per million and extremely close to the limit of 550 parts per million which is equivalent to 2 celsius degrees) forecasting an increase in 6 celsius degrees by 2060 which will cause several natural catastrophes (Grant, 2016), radical change is not yet seen (EEA, 2017). Climate change impacts all type of ecosystems and their biodiversity affecting their capacity to deliver ecosystem services. Different regions in the world show different types of impacts, for instance the North-western region of Europe expects an increase in winter precipitation, increase in river flows, Northward movement of species, decrease in energy demand for heating, and increasing risk of river and coastal flooding which are different from the Mediterranean region, where temperature rise larger than European average, decrease in annual precipitation, decrease in annual river flow, increasing risk of biodiversity loss, increasing risk of desertification, increasing water demand for agriculture, decrease in crop yields, increasing risk of forest fire, increase in mortality from heat waves, expansion of habitats for southern disease vectors, decrease in hydropower potential and decrease in

summer tourism and potential increase in other seasons, is expected (EEA, 2016). Vulnerability to climate change is also different and some ecosystems are more vulnerable than others. Indeed, the impacts of climate change on urban ecosystems are of significant importance worldwide since they accommodate the majority of the human population and generate the highest proportion of a country's wealth. For instance, currently in Europe around three-quarters of the population live in cities and the tendency exhibits an increase of this proportion to 80% by 2050. Similarly, about 70% of Europe's GDP is generated by cities (idem). In the case of the global south, the situation could be categorized as worse, since the urbanization rates are spiking as a result of the migration of rural population to cities because of economic hardships sourced in plummeted crop yields affected by extreme climate and severe natural disasters, among others. Moreover, the particularities of urban ecosystems such as urban design and planning policies alter the impacts of climate change leading to additional effects. Urban environmental issues, such as the urban heat island (UHI) effect, air pollution, increasing runoff rates due to land sealing and persistent spread of urbanization into areas potentially prone to river flood, exacerbate the consequences of climate change (EEA, 2017). In fact, an analysis on european cities demonstrates that on average 46% of the functional urban area, FUA, has a low capacity to mitigate floods, which intensifies the importance of strategic implementation of urban green infrastructure (Maes et al., 2019) to build climate-resilient cities. As just mentioned, within the available solutions, strategic spatial planning for GI gains attention and it is seen as the most promising alternative (Sussams et al., 2015) due to the capacity to support multiple policy objectives such as carbon sequestration, halt urban sprawl, increase accessible green areas for recreation and drain excess of rainwater (EEA, 2016) as shown in the ecosystem services section. In fact, scholars state that the cooling effects of urban forests could be even more important in mitigating the impacts of climate change than the efforts to reduce greenhouse gases emission (Sussams et al., 2015).

Currently, cities are including the climate change challenge into their agendas through different initiatives that include the Covenant of Mayors for Climate and Energy, Compact of Mayors, C40 with adaptation action, Making Cities Resilient (UNISDR), European Green Capital Award, European Green Leaf Award, Metropolis no regret charter and Rockefeller 100 resilient cities (idem).

1.3.3 Climate change adaptation and mitigation

Moreover, when developing strategies for climate change impacts, it is important to differentiate the indicators going towards adaptation and the ones towards mitigation because some projects may not be adequate for both objectives at the same time. Examples of indicators to assess mitigation are the amount of carbon sequestered, maintaining existing stock of carbon, decreasing greenhouse gas emissions through demand reduction; decreasing greenhouse gas emissions through supply reduction or increase carbon storage. Differently, indicators for adaptation account as an example, for how much flooding damage has been avoided or seek to maintain and increase ecological resilience (Naumann et al, 2011b). Thus, some initiatives have an impact on either adaptation or mitigation and some have impact in both policies as shown in table 6 but all have different indicators to measure achievements according to the supporting policy.

Project	**Climate change adaptation objective**	**Climate mitigation objective**	**Biodiversity conservation objective**
Restoring Peatlands	n/a	Increase carbon storage capacity and reduce CO2 emissions	Increase the number and abundance of wetland species
Habitat restoration and creation of flood storage sites to adapt to coastal change	Addressing flood protection risks	Transforming the island into a net carbon sink rather than a source of carbon	Offset historical losses of coastal habitats
Reconnecting the river Regge to its original catchment basin	Flood prevention/security/drought protection	n/a	Creation of an ecological corridor

Table 1. Examples of synergies between three policy objectives. Table adapted from the report Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe (Naumann et al, 2011b).

1.4 Spatial Planning

1.4.1 Regional and urban planning

Spatial land-use planning influences the distribution of activities in space (Meerow, and Newell, 2017) and that distribution influences the dynamics of society and natural ecosystems. For instance, sustainable development models such as the compact city, that enables higher efficiency of energy use and transport, may include less nature and less urban green areas in the city (Haughton, 1997) which challenges the implementation of GI due to a high competition for the use of land (EEA, 2016). Additionally, higher pressures in the urban ecosystem caused by an increase of economic development and tourism may accelerate the reduction of urban green areas (GRETA, 2019). Those two situations are especially true in highly populated cities where urban densification goes along with urban growth (GRETA, 2019) and a reduction of natural areas gives as a result a weakened connection between nature and society, affecting their well-being and threatening the protection of nature by not acknowledging and benefiting from ES. Those threats suggest to seek for “an intelligent urban design that uses every available space for green infrastructure” (EEA, 2016) and to analyze how cities can grow without losing GI and how GI can be implemented in urban policies for climate adaptation to increase quality of life. These two questions that require the establishment a link between ecosystem’s data and socio-economic statistics, were explored in the ENROUTE project, leading to the conclusion that detailed mapping of urban green infrastructure is a key tool for informed decision-making (ENROUTE, 2019). As an example, Antwerp, a city participating in the ENROUTE project, raised the key question of “how to develop a city master plan green and blue infrastructure based on multi-functional ambition levels, supported by related maps and indicators” (Idem, pg. 14). As a result of the project, the city has developed and launched a platform called the GroenTool (green tool in english) that aims to display maps at high resolution (10 m) of the urban needs in terms of environmental issues and suggest types of green infrastructure according to the main challenges identified in the area of interest. This digital tool allows city planners to take into consideration the importance of increasing urban green spaces and the way to apply their key ES (ibidem). However, all the previous information accounts for only the local spatial planning scale, and as it has been explained in the section of principles of GI, it is important to manage planning and information at multiple scales to strength the benefits of GI and ensure coherence between strategies. In fact, this

principle of GI is stated in one of the conclusions of the ENROUTE report (2019):

"better integration of the urban and regional planning of green infrastructure is necessary in order to strengthen the connectivity of the Natura 2000 network and take into account overlaps between functional urban areas and Natura 2000 sites".

So the development of a regional plan that includes a GI strategy could support local initiatives by becoming the guide for local planning. Thus, in terms of defining a clear and leading area of study for GI implementation, it is said that:

> "The city-region is large enough to be strategic with identifiable ecological hubs and links yet not too large to be remote from community level activities and local delivery plans that consider green-space as public amenity" (Szulczewska et al., 2017, p.2).

Understanding these connections between scales and following the ES approach that includes the concepts of pressures, conditions and objectives, displayed in graph 4, makes it easier to establish the influence of spatial planning on sectoral objectives. To exemplify this statement, it is enough to analyze graph 4 and establish a connection between policy objectives such as biodiversity protection, climate change mitigation and adaptation, provision of a healthy environment and promotion of social inclusion, and ecosystems conditions such as percentage of open urban green spaces and protected areas or status of the hydromorphological or soil-sealing-rate. These ecosystems conditions could be translated into indicators providing important information used by spatial planners to secure the land for nature conservation purposes. That is the case of Germany, where this information is used by landscape planners to justify the need of nature protection versus other sectoral objectives.

At the european level the sectoral policies identified to be "most integrated with spatial planning include environmental policy and transport policy" (COMPASS, 2018). In fact, spatial planning, in what respects to the environment, takes into account information from the Strategic Environment Assessment (SEA), the Environmental Impact Assessment (EIA) and the Environmental Liability Directive (ELD) among others (Naumann et al., 2011). This close integration to environmental policy supports the implementation process of GI by respecting through permits and assessments the orientations given by the GBN strategy to protect natural resources. Here it is important to note that the development of a GI strategy may require to have an environmental planning department that advocates for the management of natural resources in a spatial planning language. Environmental planning depends strongly on the planning system of each country and even among european countries, the systems are not homogeneous (Von Haaren & Albert, 2011). For instance, some of them focus on individual issues such as air (pollution) or water management, while

others share a more holistic approach as is the case of the German planning system called the Landscape Planning:

> It “is a very comprehensive environmental planning based on information about ecosystem goods and services. It covers most subjects of environmental protection in their spatial relevance and has been developed in Germany as a separate field of planning in the framework of spatial planning since decades” (Idem, pg. 151)

As already mentioned, the advantage of this planning system is its capacity to include environmental objectives into spatial-decision-making by providing the relevant information needed. Although this planning system seems to follows the concept of ES as described in previous sections the system introduces another concept more familiar to spatial planners: the Landscape functions.

1.4.2 Landscape Functions

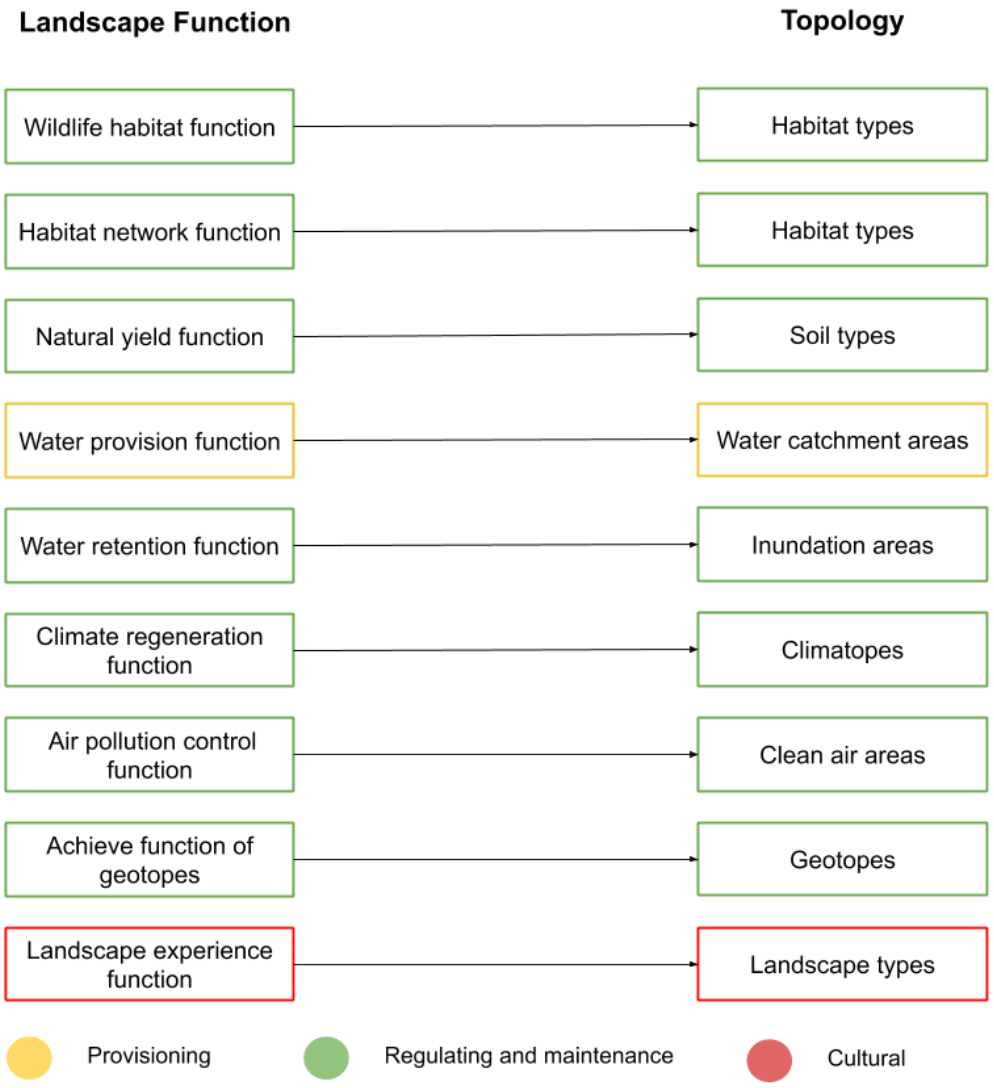
The earlier sections of chapter one have introduced the concepts of climate change, sectoral policies, green infrastructure and ecosystem services. Through all these concepts and their connections, there is no doubt of the importance of implementing green infrastructure to guide the development of the territory but also to support efforts on current environmental challenges such as climate change and biodiversity loss. However, the implementation process is not as clear as the theory suggests and at the same time the use of this terminology and the acknowledge of the need to introduce multifunctionality and environmental issues into spatial planning is not quite adopted yet by planners. Nonetheless, the two cases studies shed light on how GI is currently implemented and what other concepts are being used to accomplish GI implementation such as the concept of landscape functions applied in the german planning system as a more suitable connection between theory and practice of ecosystem services (Von Haaren & Albert, 2011). Thus, a brief introduction of landscape functions is provided through the following chart and in later sections the explanation will be expanded using the analysis of the case study: the region of Hannover.

Graph 5 shows the nine landscape functions used in the german planning system, which has a special section that advocates for nature conservation called landscape planning. In this section of planning, individual natural resources, managed as units, are assessed based on their landscape function which means the current condition and the development potential to deliver an environmental function (Haaren, Galler & Ott. 2008). Information of soils, geology, bodies of water, air and climate, fauna and flora, is thus used to deduce the performance and functions of those units and/or the balance of nature and the landscape overall (Idem).

The interest of this german concept of landscape functions lies on the idea of assigning to all landscapes units a value. Having all the landscape units identified and assessed according to their values, makes the process of prioritization and weighing, carried out at regional scale for land-use allocation, a more transparent and just process.
In order to facilitate the connection between the concepts of ES and landscape functions, graph 5 shows a possible organization of the landscape functions using the same categories applied to the ES: provisioning, regulating and maintenance, and cultural.
Landscape functions are linked to natural resources such as soil, water, air and climate and flora and fauna, which are required to achieve nature balance and lead to sustainable development. The laid out landscape functions in the landscape planning document published by the federal agency of nature conservation are:

1. Biodiversity function (biotope function, biotope development potential, species und biocoenoses)
2. Natural yield function (Natural fertility, sensitivity to erosion, compression, contamination)
3. Water resources function
4. Water pollution protection function
5. Retention function
6. Climate function
7. Landscape experience function
8. Multifunctional areas (areas with high significance of different landscape functions) (Idem)

Which are the same ones displayed in graph 5 since biodiversity function takes into account wildlife habitat and habitat network function and both water provision and water retention function oversees water pollution protection. The important feature of this concept is that all the managed area is covered by units with their corresponding functions, thus, there is not a space without a value. This key concept of giving to all but mostly to natural areas a value, provides a clear tool to protected them against urbanization, one of the land-grabbing pressures as seen in the following two case studies.



Graph 5. Adapted from lecture given by Dr. Frank Scholles. Institute of Environmental Planning. 2019.

Chapter 2: Case studies

2.1 Selection

The two cases studies are selected based on the results of the research carried out by Simona Grădinaru and Anna Hersperger (2018). They analyzed the strategic plans of urban regions or city-regions according to the GI principles. They reviewed 14 cases studies in Europe and ranked them according to their performance in each of the following categories, (using an scale of strong consideration, poor consideration and not considered for all the principles assessed except the coordination principle which was assessed using domain not considered in the plan, not coordination, weak coordination, and strong coordination):

- Coordination
    - Built-up development
    - Water management
    - Climate change mitigation
    - Food provision
    - Quality of life
    - Air quality
    - Cultural assets conservation
- Multi-functionality
    - Social functions
    - Ecological functions
    - Economic functions
    - Cultural functions
- Connectivity
    - Structural connectivity
    - Functional connectivity for animal and plant species
    - Functional connectivity for humans
- Multi-scale planning
    - GI part of a national network
    - GI part of a regional network
    - GI planning at local (municipal) level
    - GI planning at neighbourhood level
    - Site specific GI planning
- Diversity
    - Large natural and semi-natural areas
    - Large managed areas
    - Medium and small natural and semi-natural areas
    - Medium and small managed areas
- Identity
    - Identity building

From this assessment, eight cities showed high general performance using the HCA dendrogram method: Hannover, lyon, London, Brussels, Turin, lisbon, Edinburgh, and Dublin. However only two of them stood out in all of the five principles (identity was not assessed): Lyon and Hannover. Thus, carrying on with this thorough study and its results,

the following analysis on the design and implementation of the GBN strategy, selected those two cities as the case studies with the intentions of finding lessons and successful practices to be shared and adapted elsewhere.

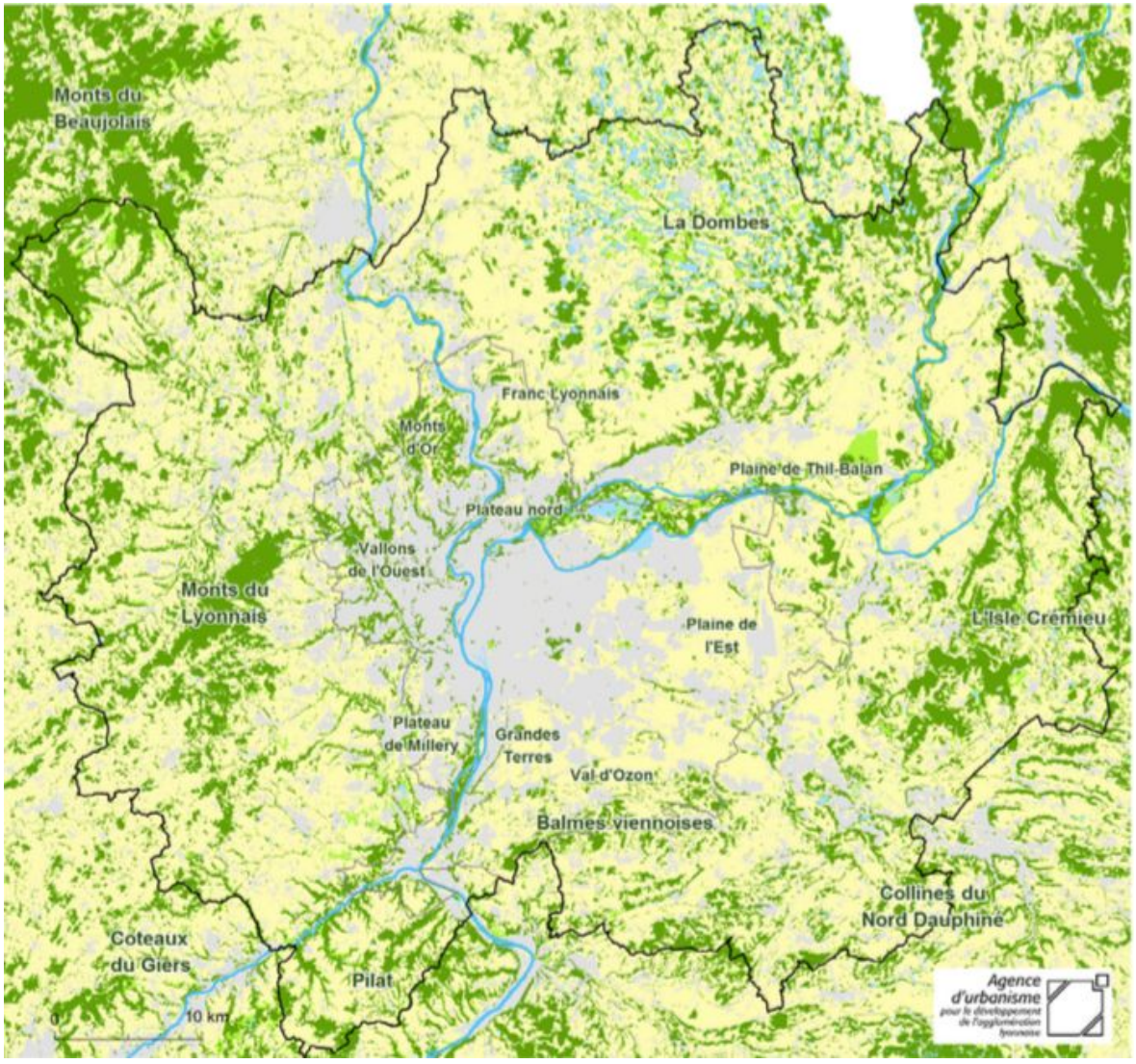
The strategic plans analyzed by Simona Grădinaru and Anna Hersperger (2018) in the case of the metropolis of Lyon were the SCOT 2010 and 2016 (scheme for territorial coherence), the PADD (project for planning and sustainable development) and the DOG (Document for general orientation). In the case of Hanover, it was the RROP Regional planning program for the Hanover Region 2015 (draft) and 2016. Likewise, these documents become the base of the current study.

2.2 LYON

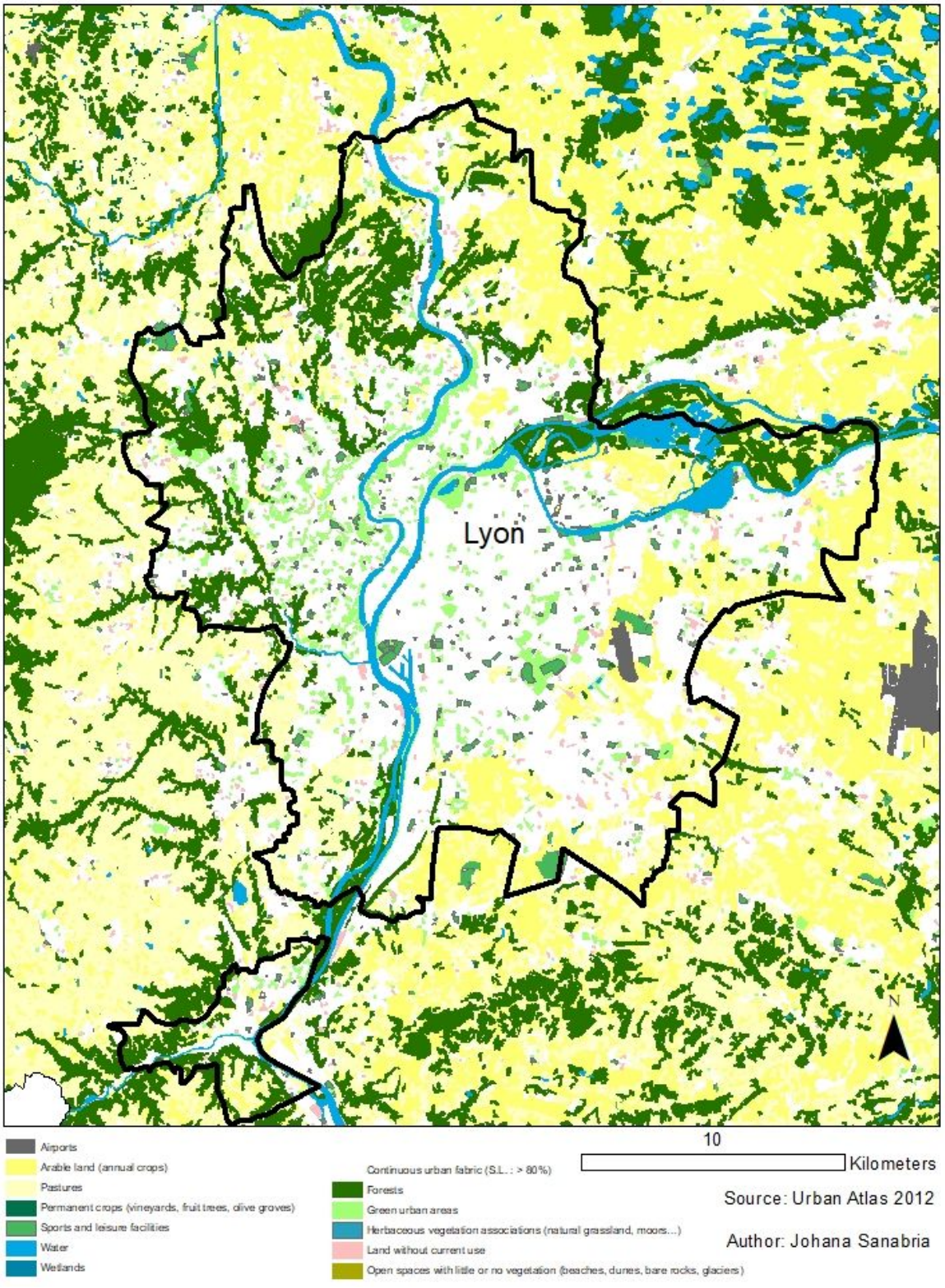
2.2.1 Introduction facts and figures

Core City: Lyon	**Biogeographic Region:** Continental
Region: Metropolitan area of Lyon + Agglomeration of lyon	**Planning Family:** Napoleonic/Regional economic
Area Core city: 47.87 km2 Functional Urban Area: 729.2 km2 (SCOT, 2017)	**Population** Core City: 506,000 (2014) - 513, 275 (2015) Metropolitan area of lyon: 1,360,000 (2010) - 1,390,240 (2015) (INSEE)
Average annual population rate: Core City: 1.44 Metropole: 0.44 Calculated as: (((Population new year/Population last year)*100) -100)/(New year- Last year)	**Public recreational green space per capita:** 6% (SCOT, 2017)
Location  Source: Natural Earth, 2014	
Lyon is the third largest city in France and recently has been ranked France's second	

most liveable city. It is located in the East-central part of France close to the Alps mountain range. The city crosses the Rhône and Saône rivers, it is located at the Rhône's plain, with mountains between 600 m to 1000 m in the lyon agglomeration, and the city's surroundings are characterized by agricultural production. The city becomes the Metropolitan area of lyon the 15th of january 2015 and it is comprised currently (2017) by 59 communes. The agglomeration of lyon is highly threatened by natural and technological risk. On the natural side, the major issue is flooding risk due to the combination of topography, geology, meteorology, the confluence of two major rivers of different hydrological regimes and the urban developments. And in the technological side the risks comes from transportation of hazardous materials (SCOT, 2017).



Map 1: Green areas of high ecological value in the Lyon agglomeration. Source: SCOT, 2017



Map 2: Green areas of high ecological value of the Metropolis of Lyon. Source: Urban Atlas 2012

The fragmentation of the natural and green spaces became the main purpose of the GBN; it is to reconnect through links the identified areas shaping a network of non-urbanizable, thus protected areas.

2.2.2 Urban and Regional planning characteristics

At the metropolitan scale the planning binding document is the SCOT – Scheme of territorial coherence. This document includes the diagnostic of the territory, the initial state of the environment, the planning project for sustainable development and general orientation (DOG). The DOO, document for orientations and objectives, is a document of translation of the SCOT orientations into the local planning, in this document the principle of Avoid, Reduce, Compensate regarding the TVB is applied. SEPAL - Syndicate of studies and programming of the agglomeration of Lyon, is the organism in charge of supervising the SCOT which is developed by Urbalyon - the office of urbanism. Urbalyon develops the planning documents for all different scales. At the level of the agglomeration of lyon, there are other SCOTs that should be coherence among them in order to avoid conflicts and set up agreements to achieve common goals. This coherence is is addressed by SEPAL who organizes bilateral meetings called scot-scot and it is explicitly expressed in the SCOT of the metropole of lyon and it is also evidenced through documents such as the landscapes of the inter-Scot. The orientations of the SCOT are influenced by other documents developed at higher scale or interests. Legally the SCOT needs to take into account the orientations of the The SCRE - Regional Schemes of Ecological Coherence Auvergne and Rhône-Alpes (SRCE Auvergne, SRCE RA), whose objective is to identify, preserve and restore a coherent and functional ecological network integrating terrestrial and aquatic environments, and of the territorial climate and energy plan (PCET). Taking into account requires "not to deviate from the basic orientations except under the supervision of the judge for a reason based on the interest [of the operation] and to the extent that this interest justifies it. Take into account refers to the least restrictive level of opposability and means that documents of lower rank must not call into question the guidelines defined by the higher standard (SRCE, 2018). The SCOT also needs to be compatible to the orientations of the SAGE - Scheme of development and water management and SDAGE - Master plan of development and water management and the PGRI - Flood Risk Management Plan (SCOT, 2017). Likewise, the orientations of the SCOT influence the city planning; those orientations should be respected by the Local Urban Plans (PLU) and sectoral planning documents such as Urban Travel Plans (PDU), Local Housing Programs (PLH), development and land acquisition projects, plan needs to show compatibility with the orientations. (SRCE, 2018). The limits of the SCOT

refer to the PIG - Projects of interest since these projects include ordinances from the state and thus the hierarchy level of importance is higher.

Administrative structure

The TVB is supervised by Philippe Mary who is in charge of the department of Resources and sustainability of the territories of the office of urbanism, UrbaLyon. He has under supervision, the department of agricultural and natural resources, the department of water, environmental quality, and health, the department of landscape and the department of prospective social and vulnerabilities. Likewise the administration of the different scales are in the same organism. The administrative chapters are 1) Approaches and metropolitan strategies 2) Local planification and 3) Urban projects (See annex 1).

2.2.3 The GBN strategy

> "The goal of the green and blue network is to halt the loss of biodiversity by contributing to the preservation, management and restoration of the environments, necessary for ecological continuity, while taking into account human activities, especially agricultural activities in rural areas" (Article L371-1 of the Code of the environment) (SCOT, 2017 pg 285)

2.2.3.1 Origins

The strategy for GI implementation in the metropolis of Lyon, called the green and blue frame or “Trame verte et bleue” (TVB) in french, has its roots in the National Strategy for Biodiversity (SNB) set up in 2004. The TVB also represents the culmination of reflections that started in the Rio Earth Summit (1992). As a result of this summit, the concept of ecological network as means to fight against biodiversity-erosion is applied in the Pan-European strategy for the protection of biological and landscape diversity (1995), which led to the SNB in France (SCRE, 2014). A particularity of the SCOT in terms of environmental issues is that the version of 2010 was developed while at the national level, the Grenelle of the environment was taking place. The Grenelle of the environment is a set of political meetings seeking for long-term decisions on the environment and sustainable development. The Grenelle led to a reform of the code of urban planning to address better the approaches on environmental issues and procedures governing land use planning. The legislative declination of the TVB was also carried out by the Grenelle of the environment (SCOT, 2017). In few words the idea of the grenelle creating the TVB:

> “Preserving the biological diversity of the living world involves maintaining ecosystems in good condition. Until now, the protection of biodiversity has mainly been based on the protection of certain protected species or protected areas known as "biodiversity reservoirs". But these remarkable areas must be inter-connected. Thus the notion of "Green and Blue Trame" was born (see Lois Grenelle), because it is necessary to preserve a coherent and functional ecological network, made up of exceptional sites, but also spaces allowing ecological exchanges, so that the entire territory is preserved” (CEN-ISERE).

The TVB is comprised by the green and the blue frame. The green frame is composed of natural and agricultural spaces that have being recognized to preservation along with their functions. The frame counts with links that connect those recognized areas and to networking links that connect to parks located inside of the urbanized area. The scale of the plots that have been digitized to materialize the ecological corridors is of the order of 1/5 000, so they are appreciable on the scale of the PLU (Cahier technique, 2015). An important aspect of the green frame is that by definition it is non-urbanizable, which reinforces its level of protection. The blue frame comprised by the rivers, streams and other aquatic environments is home to a biodiversity that needs to be better protected as well (SCOT, 2017).

However, it is important to highlight here that the blue frame is more protected than the green frame since it is covered primarily by the water framework orientations translated through the SDAGE and SAGE. Additionally, an important cornerstone happened in 1998 with the Blue Plan. This plan started a change on the perception of the Rhône and Saône river banks by integrating them to urban planning policies and reclaiming them from cars. Results of this change are the continuity of public places on the banks of the Rhône river between the Gerlandau Park and the la Tête d'Or park, and the construction of the Museum of Conferences. Although, the corridor project has received criticism for obeying more to the city dwellers’ need of recreation spaces rather than a truly ecological sense (Wiesztort, 2015), the blue plan certainly opens space for more conservation measures.

2.2.3.2 Elements

The TVB is identified by the Scot as non-urbanizable, it incorporates all unalterable natural sites, areas of landscape interest, areas of highest value for biodiversity recognized by the different inventories (ZNIEFF, prefectural order for the protection of biotopes, wetlands) and

the Miribel-Jonage Natura 2000 site, as well as all agricultural areas. The blue network determined by the SADGE completes and integrates with this green frame (DOO, 2017).

1. The green frame

This section of the network is the closest one to the urban tissue and it also includes urban parks of considerable size. It used to comprise the green V, the Grandes Terre, the Vallons du Lyonnais and the Val de Saône. However, currently the green V is no longer part of it since projects of general interest such as the creation of a second stadium have found this area suitable for its development. As it will be discussed in the next chapter, the protection given by the TVB to agricultural areas is not as strong as it should be and along with the limitations of the SCOT, the document that holds the strategy, sealing the land for those type of projects is still easy. These flaws threat the effectiveness of the GI strategy. In this case it is important to notice that the east side of the metropolis was relying on the V vert to regulate urban extension, so after removing the protection over the area, it becomes more vulnerable and it makes the pressures over the next element, the green corone also known as the green belt, higher in what relates to urban expansion management.

2. The green crown and the agricultural zone

Periurban agriculture is a very important asset for the growing population of Lyon. This protected area comprises the agricultural lands and thus becomes an important element of the inter-scot discussions. The green crown or green belt has the objective of controlling the urban front of the agglomeration. According to the SCOT two elements of the crown had a high relevance the plateau of Franc-lyonnais and the plain of Lyon to the east, which extends towards the south by the plain of Chandieu-Heyrieux and the val d'Ozon. However, it creates a bit of contradictions when the other projects such as the one described above are given higher priority and give as a result a higher burden.

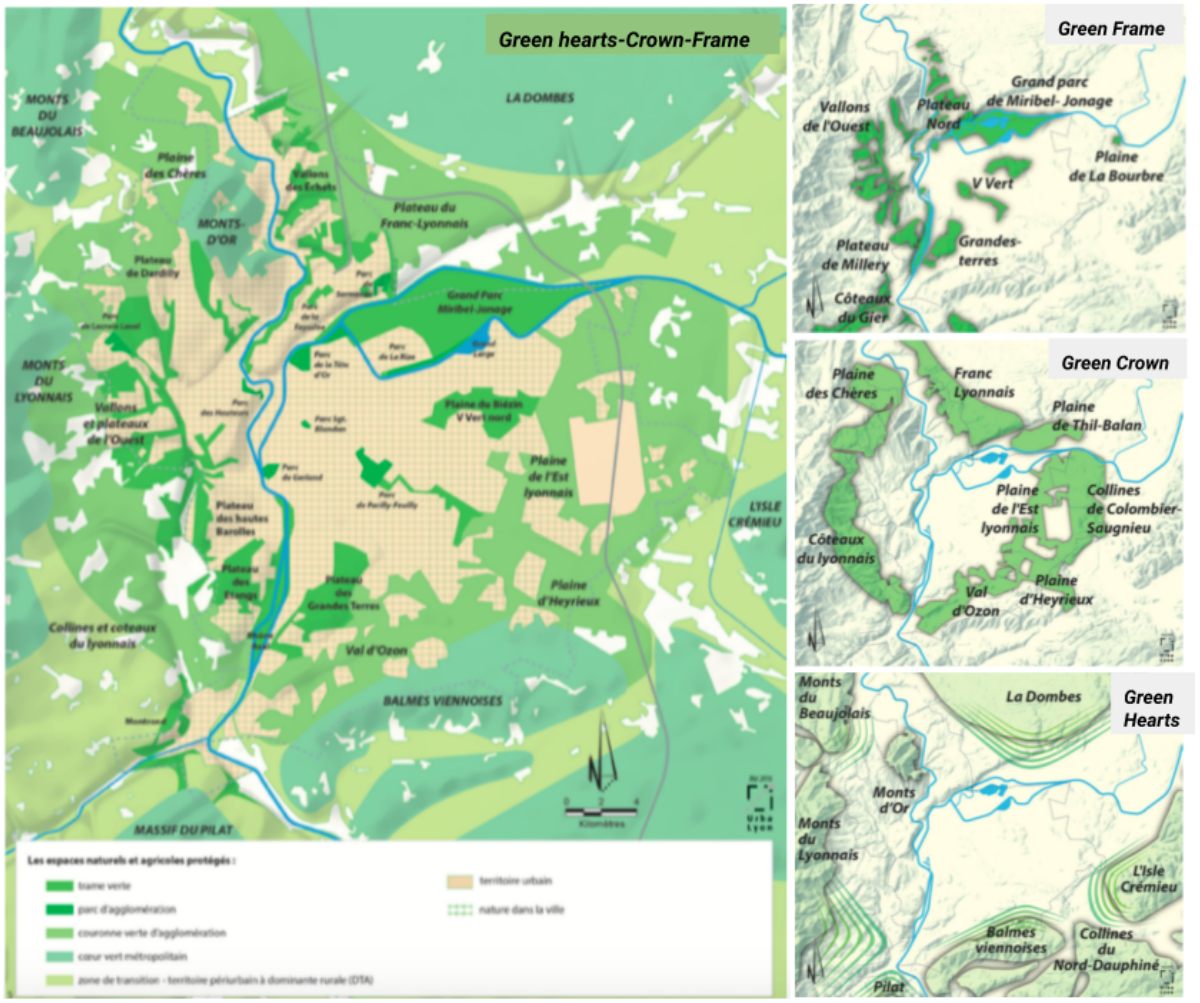
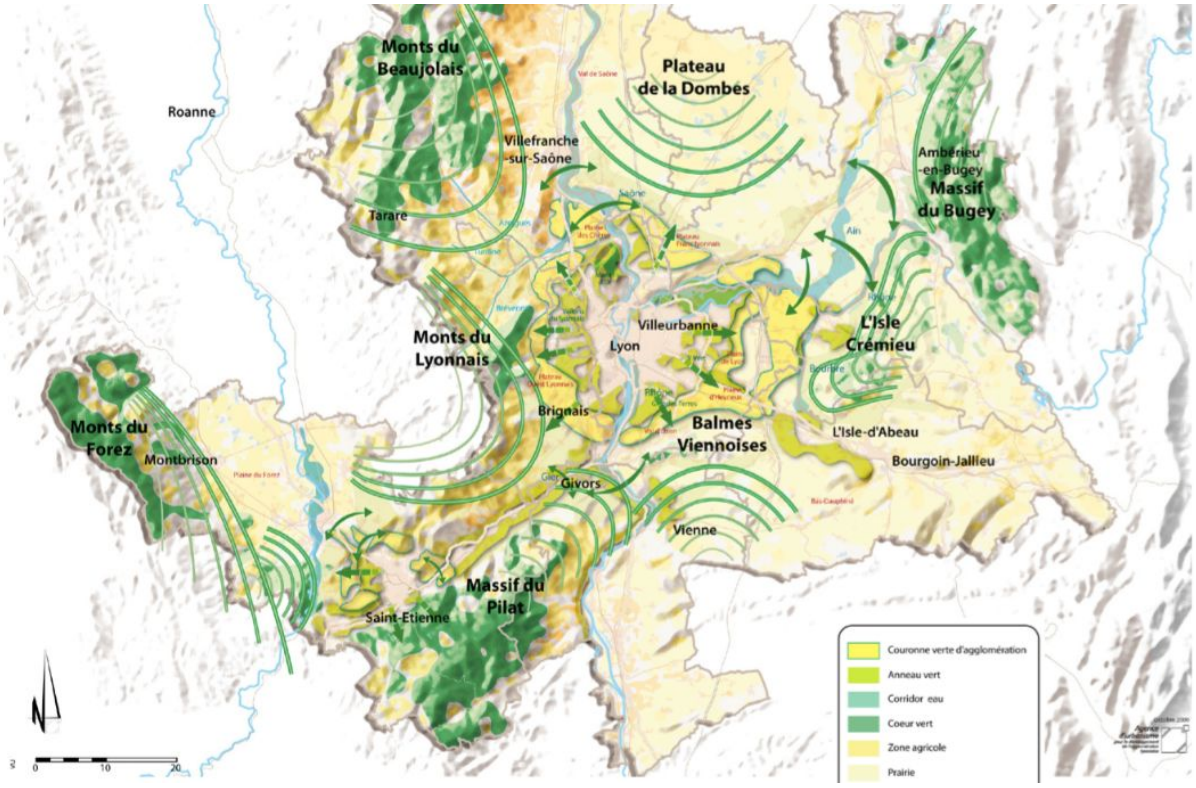


Fig 1: Elements of the green network strategy of the Metropolitan area of Lyon. Maps adapted from Document d'orientation et d'objectifs (DOO, 2017) and Project d'aménagement et de Développement Durables (PADD, 2017).

3. The green hearts

Third constituent element of the mesh network, shown in Map 6, is the green hearts (Monts d'Or, Pilat and Viennese Balmes on the perimeter of the Scot). They are part of the ecological inventories ZNIEFF and become biodiversity reservoirs like the Miribel-Jonage, the valleys in western Lyon, the aquatic corridors of regional importance such as Saône, Rhône and Ozon, and the Rhone wetlands. These biodiversity reservoirs are zones rich in biodiversity, where species animal or plant can achieve all or part of their life cycle. All those areas should be preserved or restored to good condition. The reconnection strategy is led by these inventories to create or restore terrestrial corridors of regional importance in the form of spindles and roads on a west-east axis on either side of the Rhone valley downstream from Lyon, between the Monts d'Or and the Dombes, between Miribel and the Dombes, on a north-south axis between Dombes and Isle Crémieu, between the valleys of the west of Lyon

and the Viennese Balmes.



Map 3: Elements of the green Infrastructure at the Lyon agglomeration scale. Source: SCOT, 2017.

4. The ecological continuities

Ecological corridors are travel routes used by wildlife and wildlife flora that connect biodiversity reservoirs. They are not necessarily linear, and may exist in the form of discontinuous habitat networks but close enough.

5. The blue frame and the corridors

The blue frame is constituted by the Rhône-Saône axis, including streams and canals, which play at the times the role of biodiversity reservoirs and corridors and wetlands. Aquifers are not part of the blue frame but are managed through the SAGE. The blue frame “must help to ensure the free movement of amphibian and holobiotic migratory fish species, but also to achieve the good ecological status of water bodies and ensure adequate transport of sediments, necessary for the proper functioning of aquatic ecosystems” (SCRE, pg. 21).

Map 4: Water courses of the Metropolitan area of Lyon. Source: SCOT, 2017.

2.2.3.2 Development

After the areas part of the TVB are being identified and the connections required to ensure ecological connectivity are localized, a feasibility analysis for the connections or links is carried out, map 6 shows the result of the analysis.

Three components are part of the analysis: corridors, obstacles-points and the establishment of the eco-landscape units (UEP), which are areas of variable size and permeability level and the areas interconnected by the ecological corridors. Conceiving the UEPs involves the assessment of the units according to the following criteria:

- heritage value of the sites (perimeters of management, protection or inventory)
- links with the blue frame
- links with neighboring UEPs (connected or related - two neighboring but not connected UEPs)
- constraints and pressures

- functionality with regard to indicator species ("expert say"). This indicator made it possible to define a level of permeability for each of the UEPs*
- possible obstacles to the circulation of wildlife within the UEP
- measures and recommendations to ensure the protection or restoration of ecological continuity.

*Functionality responds to two main issues: The capacity to welcome each of the 15 species (3 of them aquatic) selected as indicators, which means to know if the environment is favorable for the targeted species. Second, the proven presence of the species according to the experts. The result of this mapping of ecological corridors and permeability of natural and agricultural areas, conducted in 2014 at the Scot level by the Urban Planning Agency and local associations, is shown in Fig 2, including 75 Eco-landscape units (UEP) (Cahier technique, 2015). On the map of connections or links at the metropolitan scale, fig 2., there is a classification of the connections, depending on how feasible the connections are. Some of the connections are possible because there are located between buildings and thus, the space in between is not enough to be functional. In the case of a project envisioned on the area of the planned corridor, the developers need to ensure ecological connectivity on the corridor and they have to finance the connection if that is not granted, they do not have the permit. “However, reality is more like the corridors are reduced or restricted. The most common situation is that the corridor goes around the project. It is possible to sue a developer if the building is on the corridor however, the tendency is to avoid these situations”. (P. Mary, personal communication, 4th April 2019).

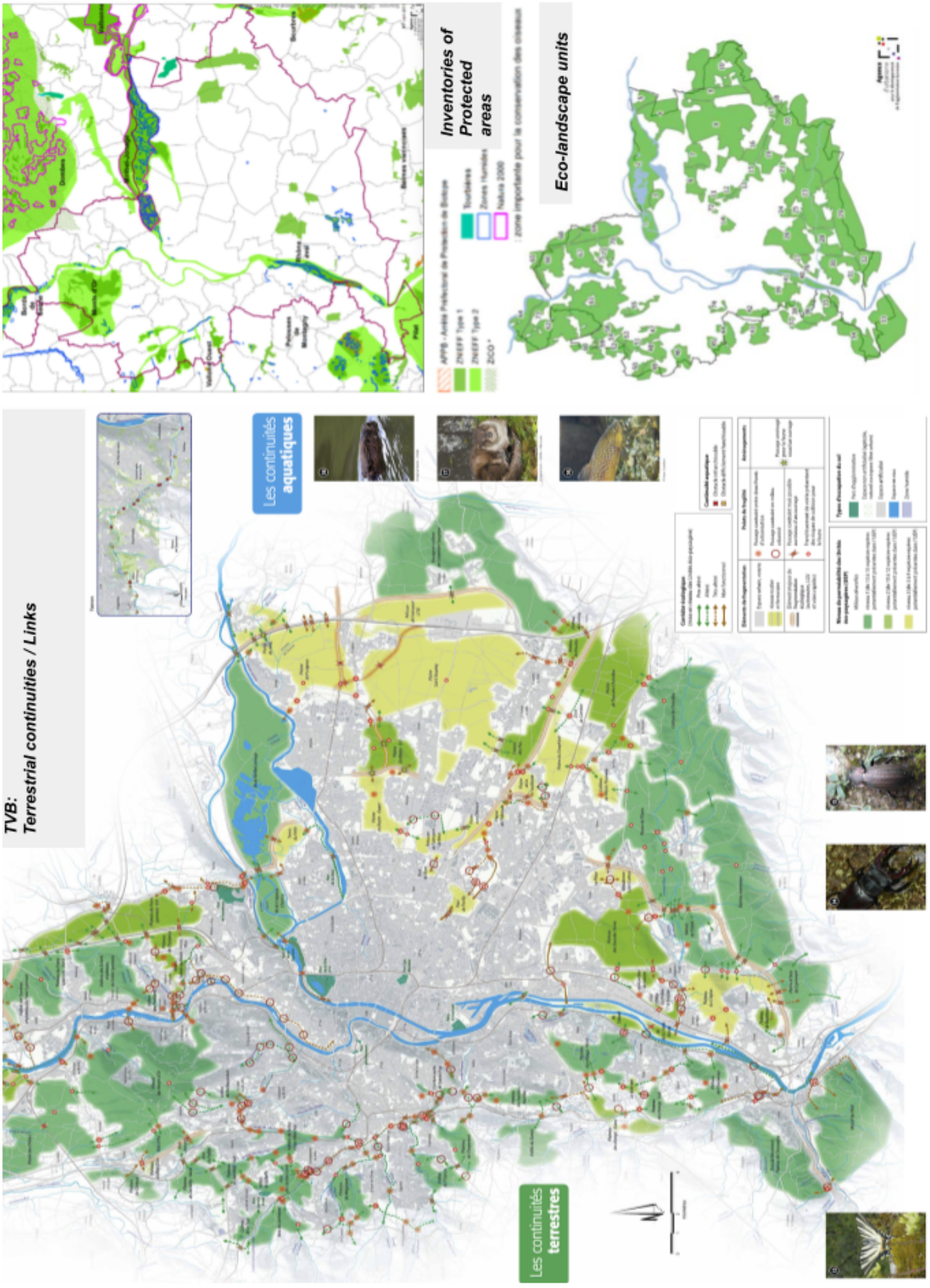


Fig 2: Important steps to develop the TVB: Mapping of protected areas, biodiversity inventories and areas delimited by the orientations of the SAGE. Determination of the landscape units and analysis of the obstacles of each connection required. Source: SCOT, 2017.

2.2.4 Analysis

2.2.4.1 Regulations

- **Land protection and compensation measures**

The main successful result of the TVB or GBN strategy is the legal protection given to natural areas, including agricultural lands, that were not protected by other policies such as the ecological inventories, through the binding document SCOT, which defines the areas belonging to the TVB as non-urbanizable. This policy is evident in the translation to local documents like the PLU where the spaces (both hubs and links) part of the TVB are kept protected against urbanization (SCOT, 2017 pg. 170) “the state council, taking into account imposes "not to deviate from the fundamental orientations except, under the control of the judge, for a motive drawn from the interest [of the operation] and to the extent that this interest justifies” (DOO, 2017 pg 9). Although the scope of the SCOT has some limitations that create flaws on this protection , there is no-doubt that the TVB is a key tool to control urban expansion and to lead financial resources towards GI implementation by ensuring ecological connectivity and restoration of the areas that belong to the TVB. Once the TVB is recognized by a legal document, any construction on the hubs or links is either forbidden or needs to follow compensation measures (P. Mary, personal communication, 4th April 2019).
The importance of protecting these natural and agricultural areas, is that the preservation of the ecological continuities inscribed in the Scot and the creation of green links for recreation has been part of this protection policy. This is the case of the second stadium “Grand Stade” built over the lands of the V vert. According to the responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, the project needs to compensate either in site by the creation of a linear park connecting to and strengthening the value of the existing park “Parc de Parilly” or in another unit of the TVB, being the park “Grand Parc de Miribel-Jonage” the most suitable one, which is also threatened by the proximity of the project. Compensation is needed for the land sealed and for the displacement of farmers occupying those lands. A current strategy already in place for this type of social compensation is the allocation of land to young farmers interested in organic agriculture.
Furthermore, the stadium case highlights two main flaws of the GBN in Lyon. Firstly, the value of the land relies only on its current status regarding biodiversity and water management, which leads in the case of the V vert, now-days comprised of lands dedicated

to intensive agriculture of non-feeding crops and mostly cereals, to have low ecological value and thus its land-use-change not representing an important issue in face of projects of general interest, PIG. Here it is important to highlight the need of including not just the current status but the potential ES of food provision on those lands. The last issue represents the limitations of the SCOT and becomes the second flaw of the policy, because, although the TVB is a declination of the national strategy for ecological diversity, other type of projects ruled by the state, can overlook the GBN strategy and artificilized significant amounts of land for purposes that contradicts the orientations of the SCOT. Moreover, this type of projects become a threat for recognized natural areas such as the Grand Parc Miribel-Jonage, also part of the TVB due to its proximity to the project (Frasca, 2012).

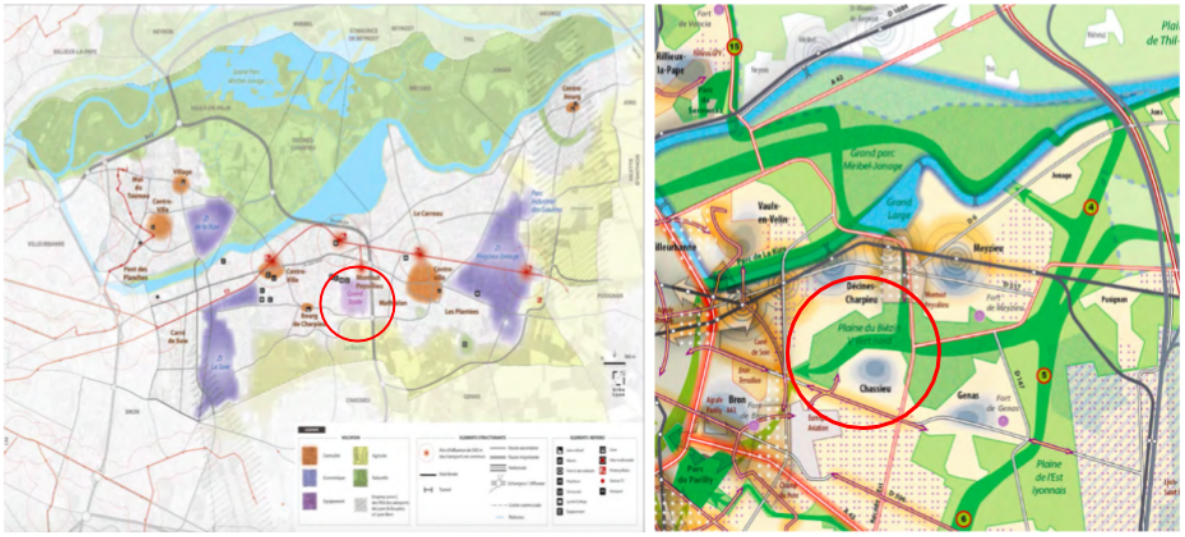


Fig 3: Location of the Stadium Grand Stade on the right, and on the left the Plain Biézin, green area part of the "V vert" (element of the green network). Source: Plan Local d'urbanism & de l'habitat (PLU-H, 2019).

Thus, although the results of the monitoring phases carried out six years after approval of the SCOT in 2010, showed protection to agricultural lands with two clear cases: the ZAP (Protected Agricultural Area) of the Biézin plain, approved in 2013 and the PIG of Plaine des Chères renewed for 3 years in 2016 (Les Cahiers de la mise en oeuvre, 2017) the need for stronger protection is still a concern for GI practitioners and planners who rather assign a PENAP classification for the Biézin plain that requires a ministerial decree to be modified than a less binding protection such as the ZAP which requires only the directive of the chamber of agriculture for its modification. A PENAP classification allows the area to be part of the PSADER (strategic project for agricultural development and rural development) to promote the management of the V vert towards market gardening by implementing organic farming.

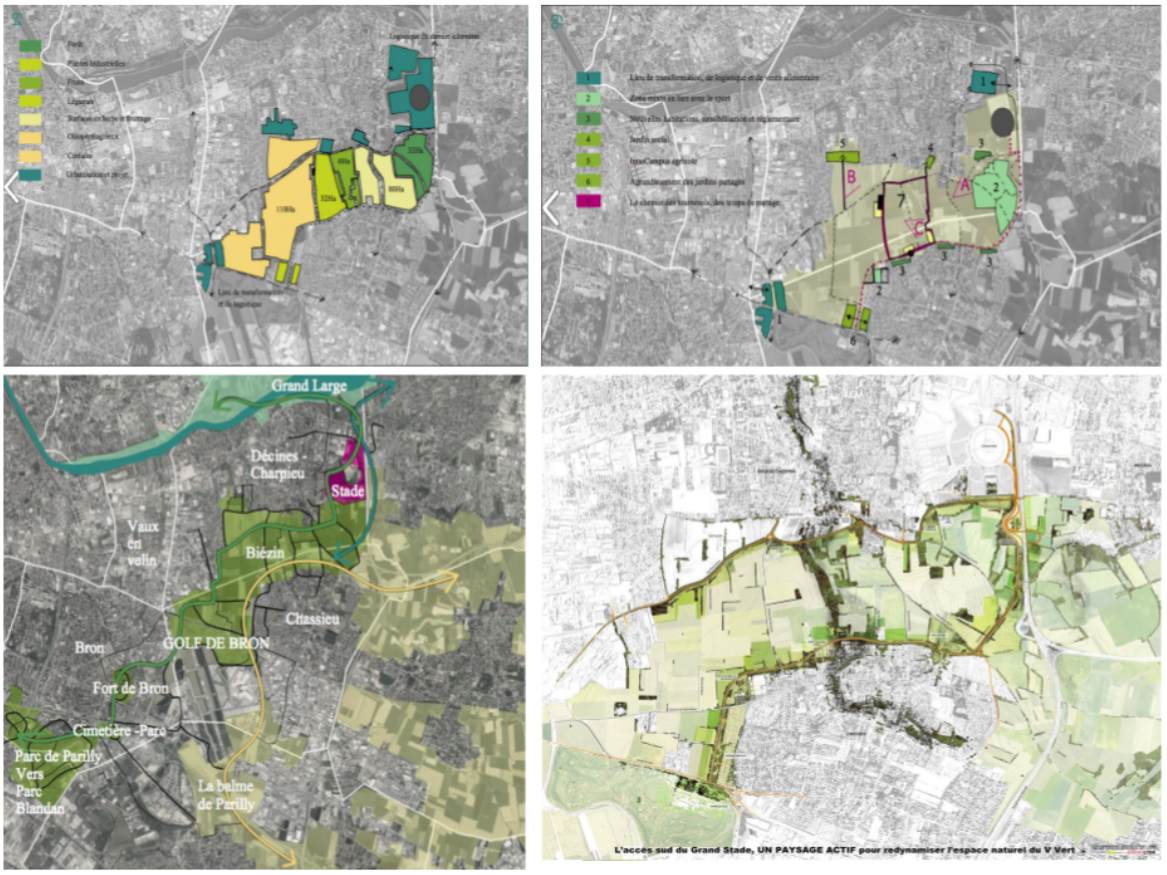


Fig 4: Initiatives to increase the value of the lands through the recognition of their potential to provide ES such as food provision and recreation paths. Source: Ilex-Issuu.

- **Ecosystem services provision as a secondary result of protection**

Moreover, the protection and restoration of these lands implicitly promote the provision of several ES, according to graph 3 (see section 1.2.2), such as provision of habitats for species and maintenance of genetic diversity, which should be expected as they are classified within the sector of biodiversity. But it also promotes ES from sectors like climate change through the strengthening of ecosystems' resilience to climate change and the regulation of water flow by protecting land from sealing. However, if the provision of the ES was taking into consideration during the establishment of the eco-landscape units, the importance of securing land for renewable energy or the importance of pollination would play an important role on highlighting the potential functionalities of intensive agricultural lands, as an example (see more on section 2.2.4.1).

- **Canopy Plan**

The canopy plan emerges as a result of the development process of the TVB, after the metropolitan approach was setted up, the interest to extend the links from the TVB into the core of the urbanization and to work in a lower scale led the city of lyon to develop a plan that seeks to spot areas with open canopy and target tree-planting projects on those areas. According to the document “urban gardening the new element to think and planify in the city” the use of ES as a concept that provides value to the projects is explicit. Indeed, according to fig 2, the canopy plan has the potential to provide multiple services such as:

- Mitigation of UHI effect since a close canopy will increase evapotranspiration and will create a source of shading and cold air, which is relevant under the high temperatures reported the last summer worldwide due to climate change. Thus, it will reduce negative health impacts from extreme heat. As in the case of the Netherlands, where studies show that 10% increase in tree cover in parks lowers the PET (physiologically equivalent temperature) by 1,5 C and in general avenue trees lowers it up to 1,6 C (Cite from urban forest). Indeed, if the canopy project doesn’t limit to avenue planting projects but creation of new parks or strengthening the forested area of current parks, similar results to the ones reported in sweden could be achieved where the PCI, park cool islands, effect extends over a distance up to 1,5 km and reaches a thermal delta of 4 or 6 C which is equivalent to the UHI effect reported in some cities (Idem).
- Climate change regulation will be possible due to carbon sequestration and the avoided carbon emissions by the sustainable transport program (walking/cycling) the city of lyon has already in place. Favouring physical activity.
- Surface water runoff attenuation and groundwater infiltration by reducing the amount of sealed soils and increasing the roots systems available for retention and filtration of water.
- Air quality improvements
- Noise attenuation

- **Monitoring plan**

The article L143-28 of the code of urbanism determines that after six years at the most after the approval of the SCOT, an analysis of the results of the scheme application, in particular regarding to the environment, transport and moving, and the space consumption to determine its continuation in force or its partial or complete revision. (Les Cahiers de la mise en oeuvre, 2017). This follow up mechanism provides continuity to the orientations of the plan and is a key element to ensure and promote the implementation of the plan at the local scale. For instance, as result of to the evaluation on land-use described in the following section, it is possible to evaluate the effect of the policy regarding land protection for nature.

2.2.4.2 Prioritization

Landuse

Prioritization of the TVB is analized throw the quantity of green area dedicated to the GBN and the funding mobilized towards it. The first point can be evidenced by monitoring the objectives of the SCOT regarding the GBN:

1. Preserve about half of the total area of the territory in natural or agricultural areas
2. Perpetuate the network as an element constituent of the multipolar Metropolis
3. Promote the strengthening of peri-urban agriculture
4. Develop leisure facilities compatible with the preservation issues of the network mesh

Regarding the first objective, despite the high rate (1,44) for the annual population change in the city of Lyon, which means a strong pressure from the housing sector along with economic development and transportation pressures, as seen in the case of the stadium, the statistics from 2010 and 2016 (six years after the approval of the SCOT) show an increment of 1% of the share of natural and agricultural spaces with a value of 53% in 2016, (approximately 15,200 hectares of the TVB, 44%, are biodiversity hubs) (Les Cahiers de la mise en oeuvre, 2017) maintaining previous orientations set up in the Master plan of 1992, which sought to keep the balance between the urban territory and the green frame (DOO, 2016). Nonetheless, the share of both natural and agricultural increased, the single value for agricultural lands ranged from 36% to 35% meaning a loss of 696 ha in those 5 years. Likewise artificialization of lands due to urbanization grew 1% meaning 541 ha for a total of 49% (Les Cahiers de la mise en oeuvre, 2017, pg 58) while the value for natural areas stayed at 16% between 2010 and 2015 and of green urban spaces at 6%. Additionally, the statistics show how in 2013 the PENAP perimeter covered 13,704 ha out of the total of 38,000 ha that belong to the TVB, however, in 2014 the coveraged was reduced to 12,653

ha. Those numbers along with the case of the V vert are clear examples of the pressures on agricultural lands and thus, stronger protection is needed to these ecosystems. Hence, the support to programs such as the PSADER-PENAP, mentioned before, is important not just to secure the land but to increase funding as seen in the results of 2014 when this program mobilized around 3.5 million euros allowing the completion of nearly 125 projects during the period of the Scot implementation (2010-2016) (Les Cahiers de la mise en oeuvre, 2017).

Fig 5: Comparison of the land-use between 2009 and 2015. A tendency of urban densification on the right side and of urban extension on the left side is observed. Source: Webarmature.

Funding

As the fig 2 depicts, the number of connections identified to be restored or built within the TVB are extensive and so it is the funding required. According to the Responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, the plan of GI at the metropolitan scale to “complete all the connections planned will take 30 or 40 years”. Thus, sources of financial resources and agreements to mobilzed them towards the works of the TVB are been sought. As a result the green and blue contract has emerged.

- **The green and Blue contract**

The Green and Blue Contracts developed by the Rhône-Alpes Region emerge as an

extension of the concept of the Green and Blue network and are operational projects that foster thinking and discussions about the development of a territory (Cen-Insere). The green and blue contract, is the tool set up by the regions to identify and finance the actions favorable to the green and blue grid (DOO, 2016). Through this financial mechanism, the region is leading communities in funding ecological restoration; in this scenario the region and the state provide the funding and at the metropolitan scale, the metropole funds very precise and punctual projects for biodiversity restoration. The green and blue contract takes place in two stages:

- a preliminary study phase: seeks to develop an action plan involving the different local stakeholders and targeting the challenges identified to improve the ecological connectivity of the area.
- an operational phase of implementation of the contract, over 5 years, with 4 components:
    - the sustainability of spaces (integration of TVB in planning documents)
    - restoration, preservation and enhancement of ecological continuity
    - improvement of knowledge and ecological function
    - the engineering of projects (animation), sensitization and communication.

A particularity of the green and blue contract is that it allows cross-financing. The Blue Frame benefits from the budgets of the local water policy Schemes of Planning and Management of Waters (SAGE), this entity identifies which connections represents a high risk and for those ones funding is provided.

However, as the responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon states, the reason for a slow process of GI implementation in the specific case of completing the works for the TVB, “is not a lack of funding but the mobilization of local stakeholders on biodiversity and the inadequacy between budgets and the extent of restoration to be conducted, especially in peri-urban areas” (P. Mary, personal communication, 4th April 2019), where it is necessary to execute other type of activities such as crossing infrastructure and improving farming practices, which increase the complexity of the main task of creating an ecological continuity.

As information provided by the responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, based on the statistics from the CGDD report of 2018, three main components constitute the national expenditure for the protection of biodiversity and landscapes in France which in 2015, was around 2.1 billion

euros, compared to 1.2 billion euros in 2000, signifying an increase of 75%:

- Spatial and species management: Management brings together actions aimed at preserving biodiversity (management of the Natura 2000 network, restoration of environments, contribution to naturalist associations, etc.). This component receives three quarters of the expenditure (1.6 billion euros).
- Pressure reduction actions: Pressure reduction operations concern actions aimed at repairing damage to landscapes and biodiversity by certain sectors (industrialists, farmers, motorway companies, etc.). This component receives nearly 500 million euros mainly financed by companies.
- Knowledge: it covers actions such as inventories or the realization of expertises. This component receives 13 million euros.

Based on the data provided, it is evident that although research efforts like biodiversity inventories, important for identification of valuable areas such as Natura 2000, are crucial for the inception of GI strategies like the TVB, but also for its development, since inventories are necessary to establish the needs of the links to be created, the funds channelized towards the component of knowledge are not comparable with funds conducted towards management and restoration of environments. So, although the extent of the work to be performed is significant and the budget required is provided, the current distribution of this budget among the tasks required to be accomplished becomes a hurdle for the TVB implementation.

2.2.4.1 Applied GI principles

Connectivity

As described in chapter 1 the three main principles of GI are connectivity, multifunctionality and coordination. The principle of connectivity is clearly applied through the GBN strategy, since the main objective of the strategy as explained in earlier sections, is to ensure ecological connectivity between the different elements of the TVB.

Multifunctionality

The second principle of multifunctionality has been also applied in the translation of the TVB from the metropolitan scale to the local scale regarding the construction of the links or corridors. The orientations and objectives for these links are described in the DOO. As the matter of fact, within the concept, it is given that these green links are the support for several functions: ecological, landscape, agricultural, leisure and discovery and their sizing is

intended to effectively ensure these different functions. The valorization of the land part of the TVB and thus, protected against construction, is given through two main functions: leisure and agriculture. Although, the corridors are meant to provide an ecological function that comes with the first principle of connectivity. The functional connectivity of the corridors is confirmed by analyzing the fauna and flora from the two cores to be connected and after the corridors are finished, a monitoring plan is carried out to verify that the identified species in both areas are effectively crossing. The corridors are also thought as spaces where people can discover different landscapes and enjoy the connection with nature. The spaces might include physical structures that foster the recreation function but in general, it will provide corridors where people can hike and benefit from those protected green areas. Furthermore, since about 36% of the areas belonging to the TVB are agricultural lands, the concept of market gardening by implementing organic farming is a compatible strategy with the land-use. This approach is already in place in the park Grand Parc Miribel-Jonage and it is sought to be implemented in the Biézin plain as described in earlier sections to increase its value and therefore its protection. These functions provide a clear example of the benefit of implementing ES when discussing the importance of GI.

Indeed, a checking list based on Fig 2, will show that the following ES are provided by the implementation of the TVB: provision of habitats for species, maintenance of genetic diversity: connecting habitats, increasing proximity of natural habitats for wild pollinators and allowing permeability for migrating species, strengthening of ecosystems' resilience to climate change as part of the biodiversity endeavour but also, due to the influence of the SAGE as it will be explained in the following section, regulation of water flows: Irrigation and drought, provision of freshwater resources and groundwater infiltration services will be part of the benefits. Likewise, soil development and soil erosion prevention, pollination and direct food, natural medicines and fibre production on the protected agricultural lands and on the ones created for the corridors. Finally, the idea of providing paths for recreation, tourism, local distinctiveness and cultural values, creates not just an improvement of mental health through stress reduction, increased cognition abilities and restored attention capacity but also creates a sense of space and nature, opportunities for education, training, art, research and social interactions. The green links projects foster sustainable transport (walking/cycling) between on park to the other which favours physical activity and therefore, supports climate change regulation by avoided carbon emissions. Finally, the protection of agricultural lands part of the TVB such as the eastern plain of Lyon, shows the economic functionality of the area since it contributes to the emergence of an economic project related to agricultural activities that provides diversification with options such as direct sales and biofuels. The

diversifitcation can guarantee the long-term viability of the agricultural crown.

Coordination

As seen with the analysis of multifunctionality, the TVB provide ES that relates to different policy sectors. The strongest coordination of this GI strategy is with the biodiversity sector since this sector is the driver to develop the strategy in the first place. As stated in the (SRCE, 2018) the Green and Blue Frame (TVB) is a spatial planning tool whose objective is to stop the loss of biodiversity by fully integrating socio-economic issues. Thus, this policy objective is achieved through the implementation of the TVB, since it is a declination of the SCRE orientations.

Regarding the water sector, the orientations of the SDGAE, which are the following, and declined by the SAGE are closely connected with the objectives of the TVB, due to the parallel development of the SCOT and the SAGE; the continued communication ensured the compatibility and complementarity of the tools. (SCOT, 2017 pg 305):

0. Adapting to the effects of climate change
1. Prioritize prevention and interventions at the source for greater efficiency
2. Implement the principle of non-degradation of aquatic environments
3. Take into account the economic and social issues of water policies and ensure sustainable management of public water and sanitation services
4. Strengthen water management by watershed and ensure consistency between land use planning and water management
5. Fight against pollution, prioritizing pollution by hazardous substances and the protection of health
6. Preserve and restore the natural functioning of aquatic environments and wetlands
7. Achieve quantitative equilibrium by improving the sharing of water resources and anticipating the future
8. Increase the safety of populations exposed to floods by taking into account the natural functioning of aquatic environments

The way these orientations are adopted through the TVB is by (SCOT, 2017- Annex)

1. Green reinforcement of non urbanizable areas with the purpose of water table recharge
2. Implementation of the blue network to strength the preservation, recovery and enhancement of rivers, aquatic environments and wetlands and restoration of continuities

3. Limiting artificialisation of soils to control runoff and allow recharge of the aquifer
4. Protection of non-urbanized flood zones or flooding expansion areas such as the plain of Miribel-Jonage through their fully integration to the green and blue network.

So, it is safe to say that the objectives of the water sector as the ones from the biodiversity sector are considered in the development of the GI strategy. However, these two sectors are the most obvious when analyzing this type of strategy and as it has seen before the financial support to accomplish the implementation of the GBN comes from those two budgets. So, the interest should go further to inquiry about for instance, climate change, pollution, human health and others.

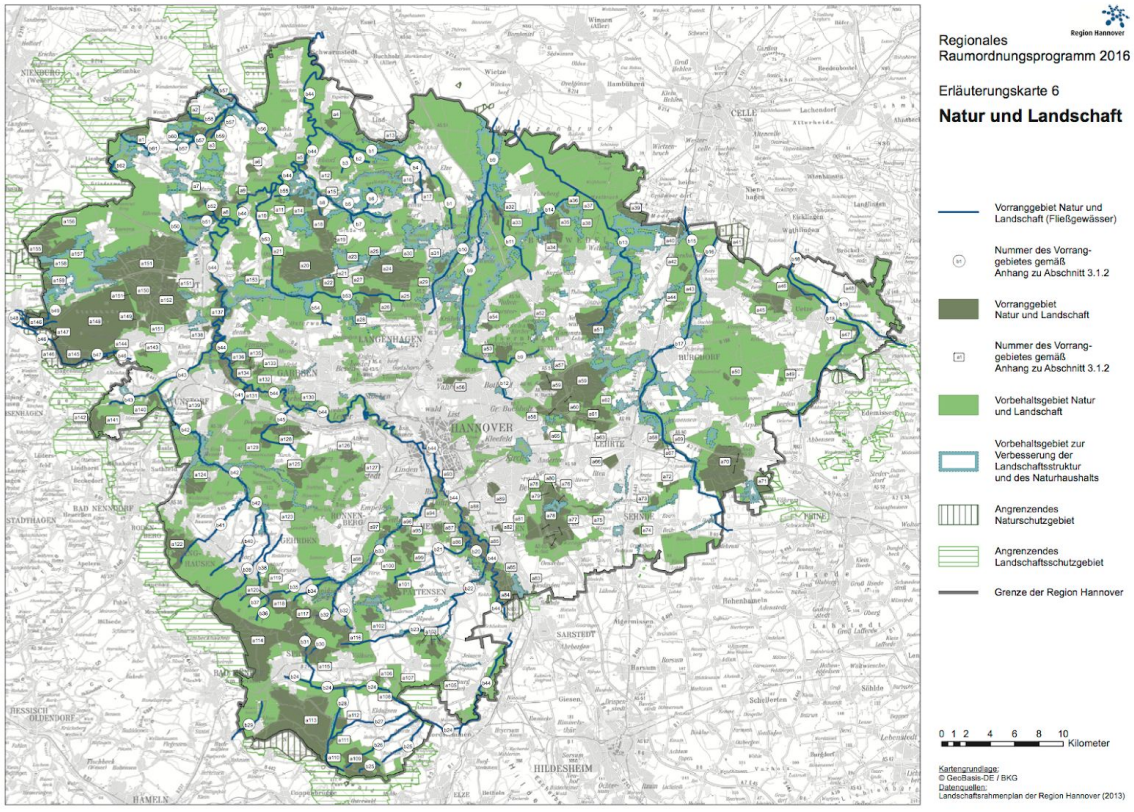
As seen in the orientations of the SAGE, the concerns regarding climate change impacts are explicit and those same concerns are translated into the objectives of the TVB. However, after the interview with the Responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, the function of the TVB as a climate mitigation tool is not recognized. The reduction in carbon emissions is perceived only as a result of the efforts to manage industrial emissions or reduction in the use of cars after a sustainable mobilization strategy has been implemented, a Climate plan is created to tackle the impacts of Climate change, this document is also opposable but it is not yet included in the last version of the SCOT. However, as seen in the earlier sections, the avoidance of using cars due to the paths created along the TVB and the carbon captured by the restoration and plantation of new green areas are efforts that support Climate Change policies and should be given more attention. Likewise, human health is a sector that is not explicitly connected to the TVB, although it is the second most important sectoral policy in european cities as mentioned in chapter one. The relationship with of the TVB with this policy is evident through the recreational and inspirational ecosystem services provided by the protected natural lands of the TVB, but it is also the ES of providing clean and fresh are and reducing noise pollution. This last one will be of most importance for the efforts conducted in the Biézin plain, area located nearby the airport. This ES are not connected with the TVB and are functions that should be analyzed, measured and considered when developing the plans for the links or other interventions in the TVB or when seeking for funding through other types of contracts similar with the green and blue contract. Finally it is important to highlight that the ES although not explicitly use are incorporated into the network and that those ES are linked to the support and influence of the sector involved. Thus, a recognition of more ES along the process of designing an GBN strategy, for instance during the assessment of the eco-landscape units analysis, the potential functionalities will facilitate the protection of vulnerable lands like the V vert of the TVB in Lyon.

2.3 HANOVER

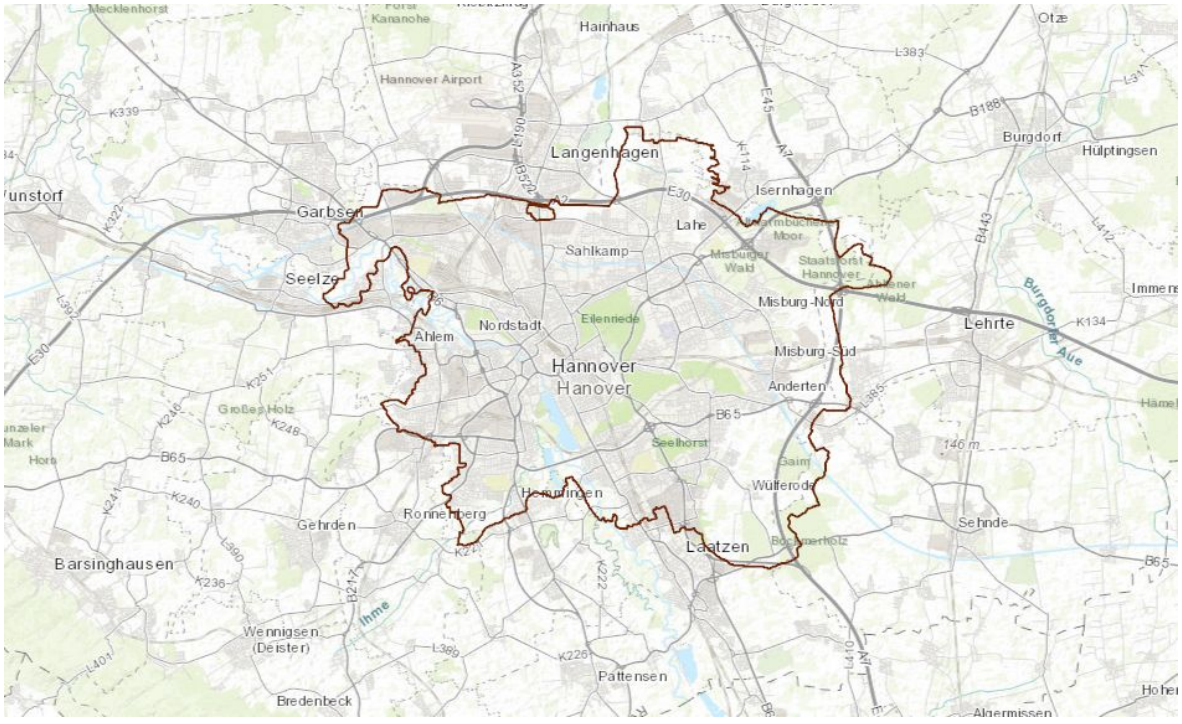
2.3.1 Introduction facts and figures

Core City: Hanover	**Biogeographic Region:** Boreal
Region: Hanover	**Planning Family:** Germanic/ Comprehensive integrated (+regional economic)
Area Core city: 204.14 km² Functional Urban Area: 2,300 km2 https://www.prospektverteilung-hamburg.de/?p=hannover-bezirke	**Population** Core City: 540,075 Region: 1,170,469 (2017) - 1,179,924 (2018) (Einwohnerinnen und Einwohner March 2017-December 2018)
Average annual population rate In the region of hannover: 0.8 Calculated as: (((Population First year/Population last year)*100) -100)/(First year-Last year)	**Public recreational green space per capita:** 11.2% (Landeshauptstadt Hannover Der Oberbürgermeister. 2017)
Location	

Source: Natural Earth, 2014



Map 5: Important natural and landscape areas in the regional plan of Hanover. Source: Hanover.de



Map 6: Boundaries of the City of Hanover. Source: ESRI.com

2.3.2 Urban and Regional planning characteristics

The planning system of Hanover is structured and it has a clear environmental component called landscape planning. The county and the city of Hanover joined together to form the region of Hanover in 2001, which included 21 municipalities. The region has a planning binding document called the RROP (Regionale Raumordnungsprogramm) which translates into Regional planning program, which includes the ordinates from the state development scheme, which is the document emitted by the Federal state. The translation of the regional plan to the scale of the municipality is done through the preparatory land-use plan. This planning system is organizational and integrative, which means that the regional plan functions as a regulative tool that coordinates development in consonance with the interests of different sectors. Additionally, it is important to mention that the planning development covers the total surface of the region and thus, all type of projects, such as the GBN strategy from the Hannover region, take part weightening process that occurs at the regional planning level to determine the land-use for each area according to the sectoral interests and the function of each area. In this way, the areas that belong to the GBN in hannover included in the regional plan, are protected against projects that do not comply to its orientations since the value of those areas has been validated based on the identified function of each habitat within the planning area and have recognize as more important than any other sectoral interest. (Haaren, Galler and Ott, 2008).

Landscape Planning

This type of planning is characteristic of the germanic planning system. It consists of a spatial environmental planning which uses the multifunctionality of the landscapes to achieve sustainable land-use. This multifunctionality is assessed using the concept of landscape units, explained in chapter one. In this way the landscape planning becomes a source of information where all natural resources are taken into account to inform spatial decisions, the later allows planners to understand the landscape situation as a whole and establish concrete objectives to protect nature, to eliminate impairments, to control compensations measures and to develop open areas for recreation, among others. (Idem)

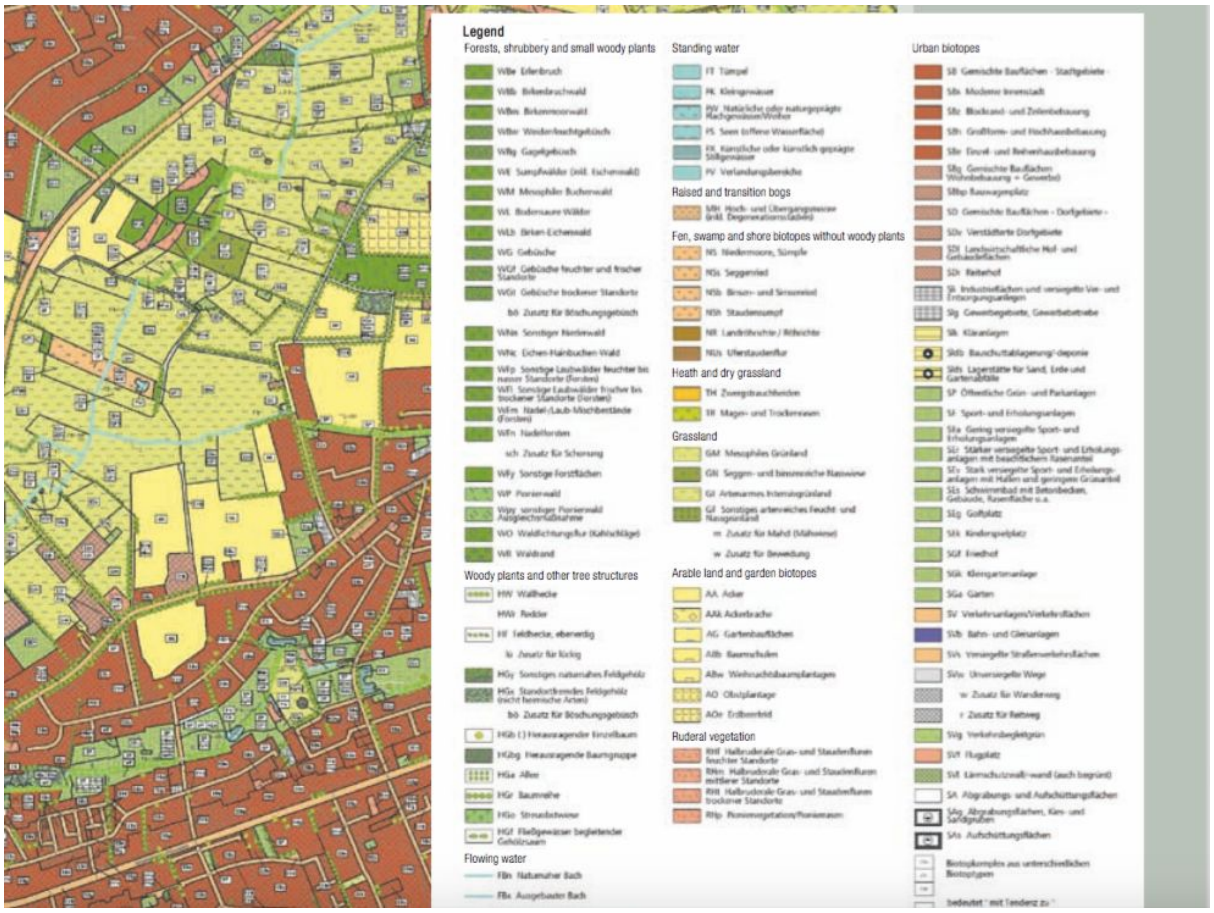


Fig 6. Example of the biotope types, information needed to define the landscape units. Source: Landscape planning: the basis of sustainable landscape development. Federal agency of nature conservation, (Haaren, Galler and Ott, 2008)

Two important distinctions to identify the protection of natural areas are shown in Map 5: The priority areas and the reserve areas.

- Priority areas
    - Within these areas (identified with a darker green color) only compatible activities are allowed. For instance, areas used for wind energy production are compatible with the agricultural land-use but activities such as mining, and housing are not and those projects will not be granted a permit. The main objective of the priority areas is to keep the green space open.
- Reserve area
    - Within these areas (identified with lighter green color) other types of activities for development that might be contradictory for the current land-use are allowed after the analysis of the reasons, if they justify the change or the

incompatibility.

Generally, the priority areas are the ones identified by the Nation conservation agency and the areas identified as important due to landscape qualities become the reserve areas.
This difference could be explained by a forested area shown in the bottom left of the MAP 5 with the light green color. Although it is identified as a important area (reserve) it is not a priority because the quality of the habitat is not unique in the whole forest, there are differents types of habitat and there are other types of land-use in the same area, such as recreational areas (cycling and hiking) and thus, the area is maintained as a reserve to keeping the balance between the needs of nature conservation and of the people's need for nature as well. But since, nature conservation is vulnerable and always need a legal protection to avoid activities that cause impairment, this differentiation of the types of protection is given in the regional plan. The analysis of the current status and the potential capacity of the area to hold a function is what determines its level of protection. It is indeed a logic decisional process that requires to have inventories of all type of landscapes or biotopes and their quality status. On the other hand, after the planning process has been done, the implementation is not pursue. One of the reasons relies in the fact that the strategies designed for nature protection rarely required a set of actions to perform, instead, the strategy should ensure the maintenance of the current status and an unchanged landscape is a sign of a successful planning (Dr. W. Jung, personal communication, 26th April 2019).
The other reason is that, as mentioned earlier, the regional plan is a regulative instrument and activities such as restoration are not a task of regional planning. Restauration can be carried out in a priority area to eliminate the impairment if existing but the scope of planning is to secure the land for special purposes so no other projects come in the way creating incompatibilities and threatening the functions of the area. The regional plan produces objectives, guidelines and provide advice but it is the responsibility of the city or the sectors to translate them into actions. Regarding this point, there is a question related to the implementation of GI strategies that require new corridors or links in addition of the existing ones since there is not a real measure to force the city or the policy sectors to do it.

Administrative structure

Around 3000 direct employees and more indirect are covered by the regional planning administrative body. All the social welfare (around 1000 employees), transport, nature protection, water protection and other sectors are in the same building, which facilitates

communication and exchange of information.

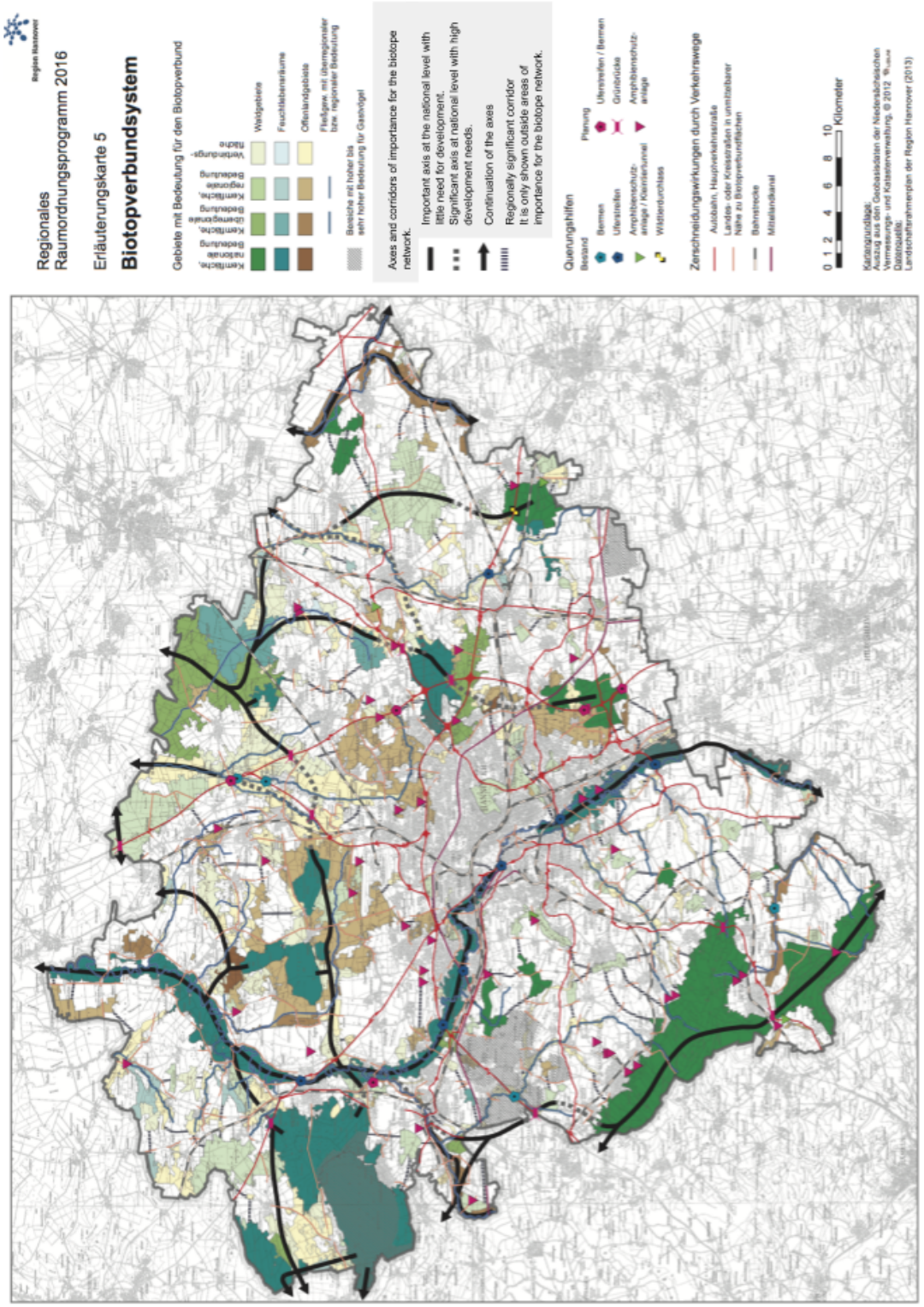
2.3.3 The GBN strategy

The value of regional planning on creating the biotope network is to be able to set up a development strategy that is environmentally sound and on the current situation of climate change, it reinforces the purpose to recognize and clarify the contributions that nature conservation provide towards the consequences of climate change.

2.2.3.1 Origins

At the national level, there is a interest to protect green infrastructure such as: “Natura 2000 sites (including OSPAR and HELCOM marine protected areas, Ramsar sites), nature conservation areas, national parks, national nature monuments, biosphere reserves (core and buffer zones), areas eligible for funding (formerly core areas) under large-scale nature conservation projects, sites with nationwide significance for the system of ecological networks (open land and woodland), core spaces for the habitat networks (dryland, wetland and woodland habitats), nationally significant axes/corridors for the nationwide ecological network and Green Belts” (Haaren et al., 2008, p 30.) in order to permanently secure native animal and plant species and their populations, including their habitats and communities. Thus, a coherent regional biotope network is established biodiversity conservation but also to ensure, restore and develop functional ecological interdependencies. The biotope network which is the GBN strategy in Hanover is the result of a logic process that includes multiple information gathered, analyzed and digitized from the ecosystems of the Hanover region and that seeks to ensure sustainable development by protecting the areas with high ecological importance according to their landscape function.

2.2.3.2 Elements



Map 7: The biotope network of the Hanover Region. Source: Regionalen Raumordnungsprogramm Region Hannover RROP, 2016

The element of the biotope network are classified as links and hubs. Where hubs are

protected areas or areas that worth of protection. The links are either new connections or corridors to be created or existent ones that should be protected, this ones being the most common ones. It is important to highlight that the areas part of the biotope network are classified as priority areas.

2.2.3.3 Development

In Hannover landscape planning has developed a set of 5 maps that provides the required information to build the GBN and also to do the translation form the Federal Agency for Nature Conservation objectives to regional planning. Catalogs to perform this translation into a systematic process are developed, symbology is either set up by the landscape planning or the federal state to in any case, facilitates communication of the new modifications in either side. For instance, a new symbol for green bridges to reduce fragmentation is required now that the biotope network has introduced the principle of connectivity. The process to develop Map 6, which is the one for the biotope network, takes into account different characteristics of the habitats in the region of Hanover. The characteristics are described as follows (Landschaftsrahmenplan, 2001) and the maps from each characteristic are shown in Map 8.

Map 1: Biotopes and species

It evaluates in 5 ranks the species and habitats to identify the value of existing habitat types and identify areas of high importance for species conservation. Red areas are worth to be protected: The ranks are 1) Biotype with very high importance, 2) Biotope type of high importance, 3) Biotope type with medium importance, 4) Biotope type with low importance, and 5) Biotope type with very low importance.

Map 2: Visual landscape or scenery

It evaluates aesthetics in landscapes.

Map 3a: Rare (biotopes)

It evaluates the soil type and how special is its value, for instance, if the land has always been used as forested area. The ranks are 1) Special values of soils, 2) Soils with special location characteristics, 3) Near-natural soils, 4) Soils of natural historical and geoscientific importance, 5) Soil of cultural and historical significance, 6) Rare soils.

Map 3b: Water and substance retention (infiltration into the groundwater)

It evaluates the structure of running waters, the bed and the banks to determine for instance if they are suitable for biodiversity. However, it is important to notice that It is not water management because it is not the quality of the water but the structure what it is evaluated. The ranks are 1) Areas of particular functionality for water and substance retention, (this feature is important for areas where there is no buffer for agricultural lands and there is an accumulation of nitrates), 2) Near-natural streams and rivers (including source areas), 3) Flooded areas with permanent vegetation, 4) Areas of high groundwater recharge / high area retention with permanent vegetation, 5) Non-dewatered low, transitional and moorland soils and boggy soils, and 6) Areas of high risk of erosion with permanent vegetation.

Map 4: Climate / air in the landscape planning. (air pollution needs)

This map shows the areas that produce fresh air and the corridors that transport the fresh air to the yellow ones which are a the areas where there is a burden.This map does not include heat-stress issues as currently is not been analyzed in landscape planning.

MAP 5a: Target Concept

This maps takes into account the results from the previous four maps. The result of having all the maps together is not really useful because, since the areas of the polygons used in the maps 1 to 4 are different and the GIS program to enable joint of the information, breaks the polygons into smaller pieces and this way allocates characteristics to the right unit or polygon. This result allows to gather more information from unit but it is not useful since it does not provide guidance for the development of a planning strategy, however it is a mandatory process of landscape planning.

MAP 5b: The Green Infrastructure map

This map, which is actually the map that shows the spatial planning strategy has emerged from the specific planning of Hannover since it is not part of the logical process of biotopes assessment and landscape-functions This maps, classifies some of the information from maps 1 to 4, but it does not include all of it. Moreover, it introduces new information that completes the basis of the information of this map, which comes from map 1, biotopes and species. Map 5b, ranks the biotope network elements according to conservation interests at different planning scales: national, regional and local relevance. The map also takes into account the research on endangered species in the Hannover and Germany, for instance the biotope network provides links for a rare cat in Germany. Regarding the maps, the

boundary lines of the landscape image units are usually spatial edges that are formed by vegetation structures (boundaries of the biotope types), structures (settlement margins) or by geomorphological aspects (low-lying edges).

Local Planning

The following two sections are based on the information provided by Ms Schunke, Member of the environment and Urban Green department for the capital City of Hanover, Germany, as part of the interview.

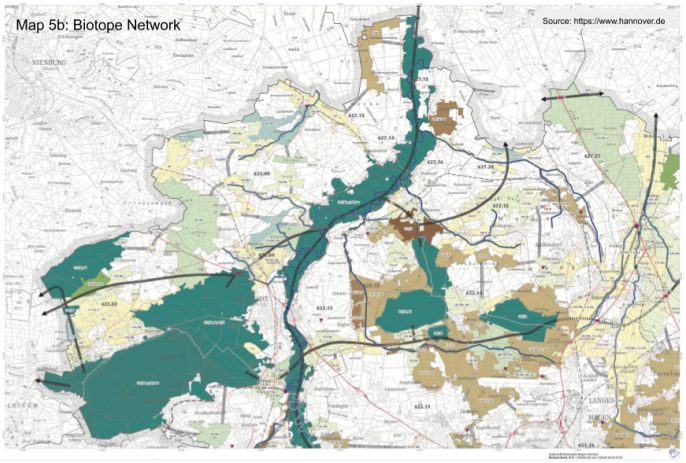
After the biotope network is developed and integrated into the regional plan, there is not an ordinance or a reinforcement to implement the strategy, there is though a protection to forbidden any construction or activity that is not compatible with the orientations of the priority or reserve areas within the biotope network. As seen in maps 6 and 7, part of the GBN is located inside of the city of Hanover, although the majority lies outside of it, it is important to see how the city takes into account this strategy and follows its orientations.

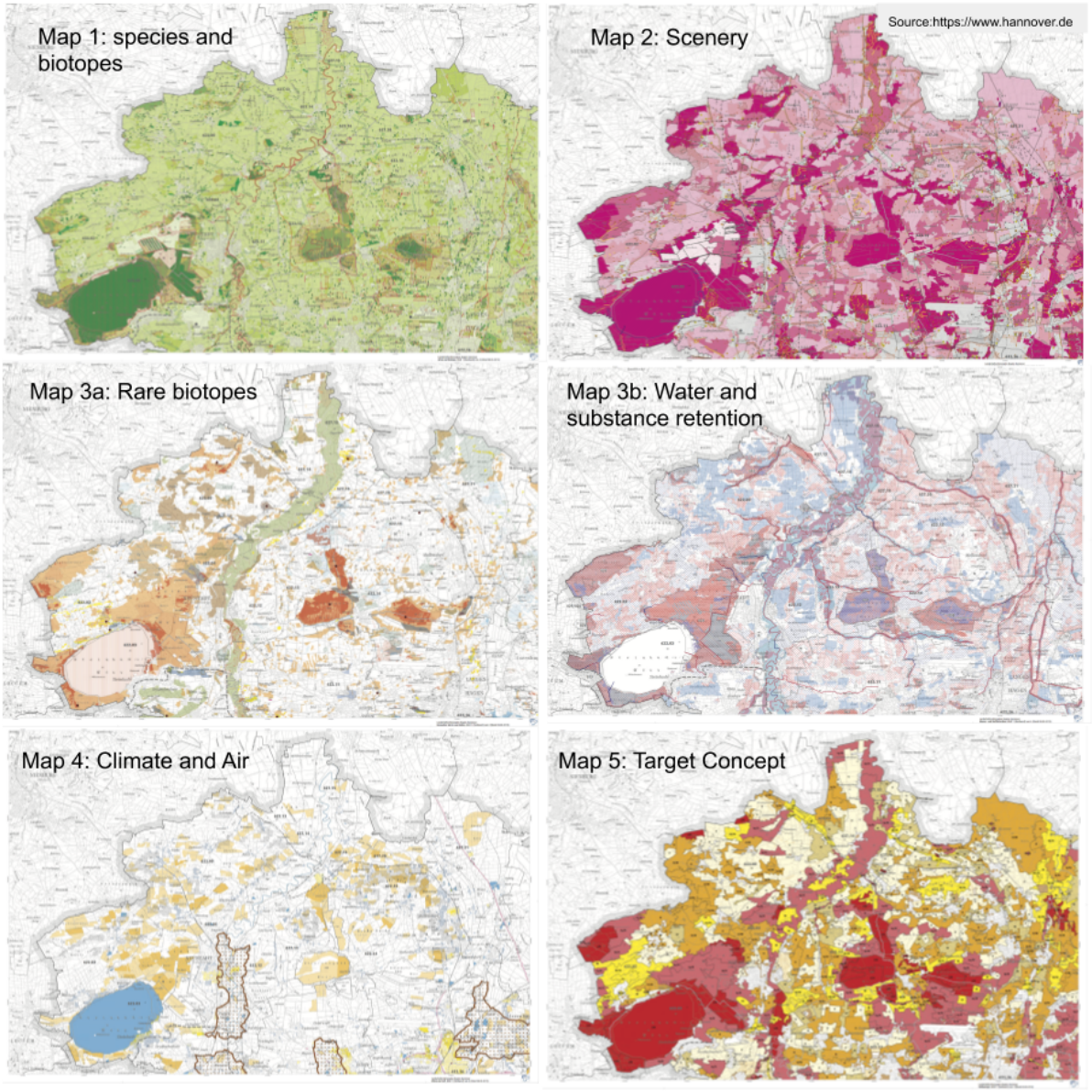
In the city of Hanover, the orientations of the biotope network are used as a basis by the open space department to provide recommendations to manage the open green areas in the city. There is an analysis of urban green spaces such as cemeteries, sport fields and playgrounds, and of the connections or corridors in between. The main purpose of the department to manage those spaces is to provide recreational benefits but according to Ms Schunke, biodiversity and climate change are also taken into account in an analysis of the future needs scenarios in the city. Through this exercise that resembles the synergies and tradeoffs analysis for ES, it is evident that not all areas adequate for recreation are also suitable areas for biodiversity within the city. Another important objective at the local level is to keep protected the agricultural land around the green belt which is threatened by the increasing population. The protection given to this green ring came 10 years ago through the Nature conservation act LSG (landscape protection area) which made it not allowed to build on it but according to Ms Schunke the protection is vulnerable to projects regarding affordable housing. Finally, although the action taken to implement GI have been scarce, the most suitable areas have been found along the blue infrastructure, one of the reasons is due to the synergies established with the water directive. For instance, water retention is an objective managed by the open areas department, so problems such as runoff are resolved by both the sewage department and the open areas department which increases the protection of land to prevent construction over it and also the budget to implement GI due to the coordination between sectoral policies. Moreover, other regulations are also implemented for this specific issue, in the land-use plan the map for infiltration capacity into

the soil determines when detention measures should be implemented in construction projects. Likewise, the strategy of the green belt and the biotopes are strengthened by the departments of biodiversity, water directives and climate change at the local level, so when an area have several multi functionalities it is harder to construct over it. The most common synergies are once again with the water directive in the case of flooding because of the risk it arises. Additionally, synergies are sought to obtain funding to create new green corridors that are complex and require a high investment; for instance there is not connection between a forested area and an area for wetlands in the city of Hanover, so, opportunities with other sectors are expected to fund the project. Prevention for land-use change is sought in every case, however when it is no possible the mitigation principle is applied to every area altered within the region of Hanover. A particularity is that the value the developer is required to pay is equivalent to the importance of the area intervened.

Landscape Functions vs Ecosystem Services:

According to Ms.Schunke, the use of landscape functions is supported by the educative component. The concept is learned by planners at university. By contrast, ES is a concept that is not applied although it is known by planners. One of the reasons is the perception as “something that needs to be quantified and it is very difficult to do that and there is not real benefit to do it for a political argumentation” (Ms. M. Schunke: personal communication, 26th April 2019); it is so difficult to deal with quantification at the local level. Moreover, landscape functions are useful not just to identify the areas to be protected but advocated for funding, normally there are subsidizing programs relevant for water functions and biodiversity. For instance, there is a program for reducing soil sealing, it is a federal program, the argument lies on water infiltration and retention function.





Map 8: The steps to develop the biotope network of the Hanover Region. Source: Hannover.de

2.3.4 Analysis

2.2.4.1 Regulations

One of the benefits of the biotope network strategy is to create a legal instrument to have all the compensation measures in one place, to gather all the funds from compensation and mitigation measures and invest them on the biotope network which ensures that restoration measures and habitat enhancement in this network will be financed as a priority.

2.2.4.2 Prioritization

Landuse

Regarding the amount of land dedicated to biotope network the objective set was to preserve and develop the spatial conditions for functional species communities through land conservation and a biotope network of at least 10% of the land area with integration of Natura 2000 sites (RROP, 2016, p10). According to map 7, the biotope network has achieved a higher percentage than the goal set. In the RROP, about 16% of the area is protected as a core area for the biotope network and around 20 to 30 was estimated to be required for connecting surfaces to achieve a spatially-functional biotope network. Thus, the core areas and the habitat corridors, or links between core areas, add up to total of 43% of the area is protected under the biotope network (RROP, 2016, Annex 5.1)

2.2.4.3 Applied GI principles

Connectivity

As in the case of Lyon, in Hanover the aim of providing corridors for important species in the planning area is one of the main objectives of the biotope network. Likewise, as explained in the previous section, the GBN of Hanover is also strongly guided by a study on biodiversity and endangered species.

Multifunctionality

The multi functionality of GI in Hanover is more evident at the local level than at the regional level. The function of the areas of the biotope are multiple and according to them the level of protection is given as explained for the priority and reserve type of protection, however one

important example of multifunctionality is the vision of setting aside areas for renewable energy. As explained earlier, activities such as wind energy harvesting and agricultural are compatible activities and thus ecological and economic functions are held in the same area. The information of each type of habitat allows to better know the multifunctionality of the biotopes and provide the respective protection while fostering other activities that are compatible. However, at the local level projects such as the increase of the amount of GI and the access to the banks of the channel broaden in 1980 and 1990 (leaving the areas next to the channel not visible and lacking of GI) shows the multifunctionality of a green corridor than besides the water retention and the biodiversity conservation functions, also has an important function of increasing awareness of the importance of having the river in the heart of the city for inspirational and recreational activities.

Coordination

Coordination of the biotope network with other sectors such as biodiversity, water management, air pollution and Climate Change are easily tracked according to the information used for the assessment of the biotopes and the planning documents. In terms of biodiversity, the biotope network aims to protect populations of wild animal and plant species that are close to extinction due to spatial isolation and reduction of their habitats. For the climate change sector, the biotope network has the potential to contribute to greenhouse gas reduction and support adaptation of the flora and fauna to climate change (Haaren et al., 2008). For the sector of water management, the biotope network includes almost all of the running water flows as priority areas. It is important to highlight that for flooding areas prone to be flooded in 100 years are under priority areas and areas prone to be flooded in 200 years, which are more extensive, are labeled under the reserve areas. But under current impacts of climate change the delimitation of those areas is in constant change and thus, the regional plan which contains the biotope network works as a guide but in housing project for instance, needs to consult the respective sector department, in this case the water directive to be informed of the current areas under priority and reserve protection since the regional plan is not changed as often as these changes in flooding areas happen. Moreover, the regional plan functions as a source of information but permits are not delivered by the regional planning, they are provided by the sectoral departments.

Chapter 3: Comparison and Discussion

3.1 Basis

Based of the analysis of both strategies it is clear that the GBN achieves to communicate the need of ensuring a balance between nature and development. In Hanover, the strategy results as a preventive action, it seeks to avoid fragmentation and impairment of the habitats, which would compromise their landscape functions. The reason is backed up on its integrative and holistic system of planning that has a long tradition of environmental protection and allows them to provide development scenarios using current information of the natural fabric. However, not all the countries, in fact only a minority of regions counts with this planning system. In the case of the metropolitan area of lyon the GBN results as a reactive strategy to act against the pressures over natural assets. Nevertheless, in this case the GBN strategy facilitated a spatial analysis using information of the current status of the existing green infrastructure and aimed to recognize its value. Indeed, in both cases, nature is seen as a valuable asset and its protection is sought through the delimitation of natural interconnected areas or fragmented areas that will be connected through green corridors as part of the strategy.

3.2 Results

Regarding the level of protection provided to the GBN in both case studies, the protection given to the biotope network is stronger since construction is not allowed and also incompatible activities to the functionality of the area are forbidden. The reason is due to the process of selection to determine the value of land. In Hanover, the elements of the biotope network are selected based on extensive inventories that show the characteristics and current status of all the existing habitats in the area and their functionalities. This information allows to identify the spatial needs and required allocation of the land to achieve the environmental objectives of the region.

In the case of the metropolitan area of Lyon, the protection goes to recognize the land of the GBN as non-buildable. In this case, the strategy is driven by the need of defragmentation and due to the lack of habitats' inventories, the selection of the elements of the TVB follows the principles of ecological connectivity at different planning scales. Thus, in the case of lyon, the selection is based on biodiversity inventories and needs for ecological continuity, thus the search for synergies and to manage the trade offs of functions or ecosystem services is seen in a later step, when funding is required. The intention to control the

development of activities that may threat the functionality of the GBN is not clear in this case as the main functionality is given by the biodiversity in terrestrial and aquatic environments. Nonetheless, the percentages of 43% for Hanover and 53% for Lyon of protected areas, provide a clear vision towards sustainable development. In both cases, nearly half of the surface of the GBN is represented by the hubs and more than half of the area is comprised by the links. The main difference though, is that in the case of Lyon the majority of links are not existent but are planned to be developed within the strategy.

Additional to the land-use protection achieved with the GBN strategy, the results on compensation and mitigation measures is a common success. In the case of Hanover the planning system already holds accountable developers for changes in land-use and they have pay and perform compensation and mitigation measures according to the value of land intervened. However, an important result of the GBN is the system to ensure that those projects and funds from mitigation and compensation go directly and only to the GBN. This will strengthen the GBN and will ensure any new corridor or restoration will be completed. Likewise, in the case of Lyon, any land-use change in the GBN, unlike the situation for any other land of the territory, is subject to mitigation and compensation measures. And similarly to Hanover, the measures are directed towards the GBN.

Finally, although both strategies were successful on their endeavor of protecting and ensuring development respects the value of natural areas. The case of Lyon does a better job on monitoring and implementation. And at this point the comparison is not easy, nor clear because although the process of monitoring and evaluation of the TVB implementation is mandatory as part of the evaluation of the SCOT, the TVB versus the biotope network does require more actions to be accomplished than the GBN in Hanover. This is because the majority of the links in the TVB are not existent and thus, need to be created which requires a significant investment. On the contrary, the elements of the biotope network are mostly delimited in the map and just few connections are required as of now. Thus, a monitoring scheme is not as required as the case of Lyon and it is worth to mention that now that the GBN in Hanover is requiring new links in some areas and the concept of climate change is being integrated into the strategy, the monitoring scheme is being analyzed for a future implementation.

3.3 Climate change

In both cases, climate change mitigation is not quite yet introduced in the GBN strategy

(initiatives to reduce car use or control emissions from industries are the ones oriented towards mitigation but not the restoration of green elements and reforestation by creation of links). And benefits for climate change adaptation has been fairly more acknowledged due to the coordination with the policy sectors of biodiversity and water management, where the concept is understood and address as a pressure for ecosystems and species. This confirms Matthews, Lo and Byrne's results in 2015, which showed the difficulties in conceptualizing and binding GI to the climate change agenda as some of the key challenges for spatial planners: "Awareness does not necessarily translate into action. Planners do not appear to be actively engaged with the concept of climate risk" and "The realization of the climate change risk hasn't really hit home [for planning]. A lot of people are aware of it but the vast majority haven't really bought into the whole concept yet."

Nevertheless, current pressure is changing this behaviour and facilitating the introduction of climate change into spatial planning as seen in the documents of the Federal Agency for Nature Conservation (Haaren et al., 2008) (Mayer and Schiller. 2017) where the benefits of GI (protecting habitats that act as carbon sinks or increasing habitats that capture carbon emissions in a faster way) for climate change adaptation and mitigation are explicitly addressed.

3.4 GI principles

The principle of connectivity is present in both strategies and it is the driver in both cases. The principle of multifunctionality is more evident in the case of hanover at the regional and local level, this is due to the concept of landscape functions. At both scales, the functions are clearly identified, however, regarding to the GBN the most used functions were the ones related to biodiversity. In the case of Lyon, there is not a clear concept behind the strategy despite of the principle of connectivity. Although the concept of ES could be seen through the valuation of agricultural areas and corridors. The projection to have bio agriculture or hiking paths for human recreation are benefits of preserving or creating green areas. The acknowledging of either landscape functions or ecosystem services would make it easier to see the importance of synergies and trade offs between functions or services and having information regarding the conditions and pressures of the habitats or ecosystems to establish regulations on land-use. Nevertheless, it is important to recognize that the development of the TVB provided an introduction to the landscape functions through the concept of eco-landscape units. Furthermore, the objectives of different sectoral policies are considered in a better way in the case of Hanover since the development of the strategy requires to take into account different characteristics of the habitats and the decision to

implement or not the strategy comes up after a weightening process where the justification for protection of the land is key.

3.5 Planning structure

It is important to highlight the simplicity on the planning structure of Hannover, the use of landscape functions to value land and the publication of maps and documents in the website for easy consultation provides not just transparency and space for public participation that complies with the Aarhus Convention but a source of information for planners in other regions willing to adopt some of the lessons from the initiatives such as the biotope network. On the contrary, the lack of a concept supporting the initiative requires more effort to understand the evolution of an initiative like the TVB, it makes it harder to follow and develop the initiative further. In this case the implementation of the landscape units or the ecosystem services will be beneficial in the valuation of natural and green areas. The biodiversity objectives are the guide for the TVB but in order to fully apply the concept of GI, and build stronger justification for the protection of natural areas under the pressures of population growth, economic development and climate change, it is necessary to integrate one of the two concepts explained in chapter one.

According to Mr. P. Mary, Responsible of the department of resources and sustainable development of the territories for the Metropolis of Lyon, France, the main problems to implement the TVB besides the lack information to justify the importance and value of certain elements of the GBN, are the lack of funding at the level of the issues to establish green links or ecological corridors and to restore the main elements of the TVB, but especially lack of local political will and the contradictions of the State in the programming of its major projects.

- Thus, once again, the adoption of a solid concept behind the GBN strategy will facilitate the valorization of the green areas. But it is also required to have:
- A weightening discussion among representatives of different sectoral policies to strengthen the importance and acknowledge of the TVB as happens in the case of Hanover when the regional plan is set.
- An integration of spatial planning that goes beyond the metropolitan scale to determine the areas to be protected in the future corridors and inconsistencies in the way the links are located at the municipal scale and the other projects envisioned on the same location.

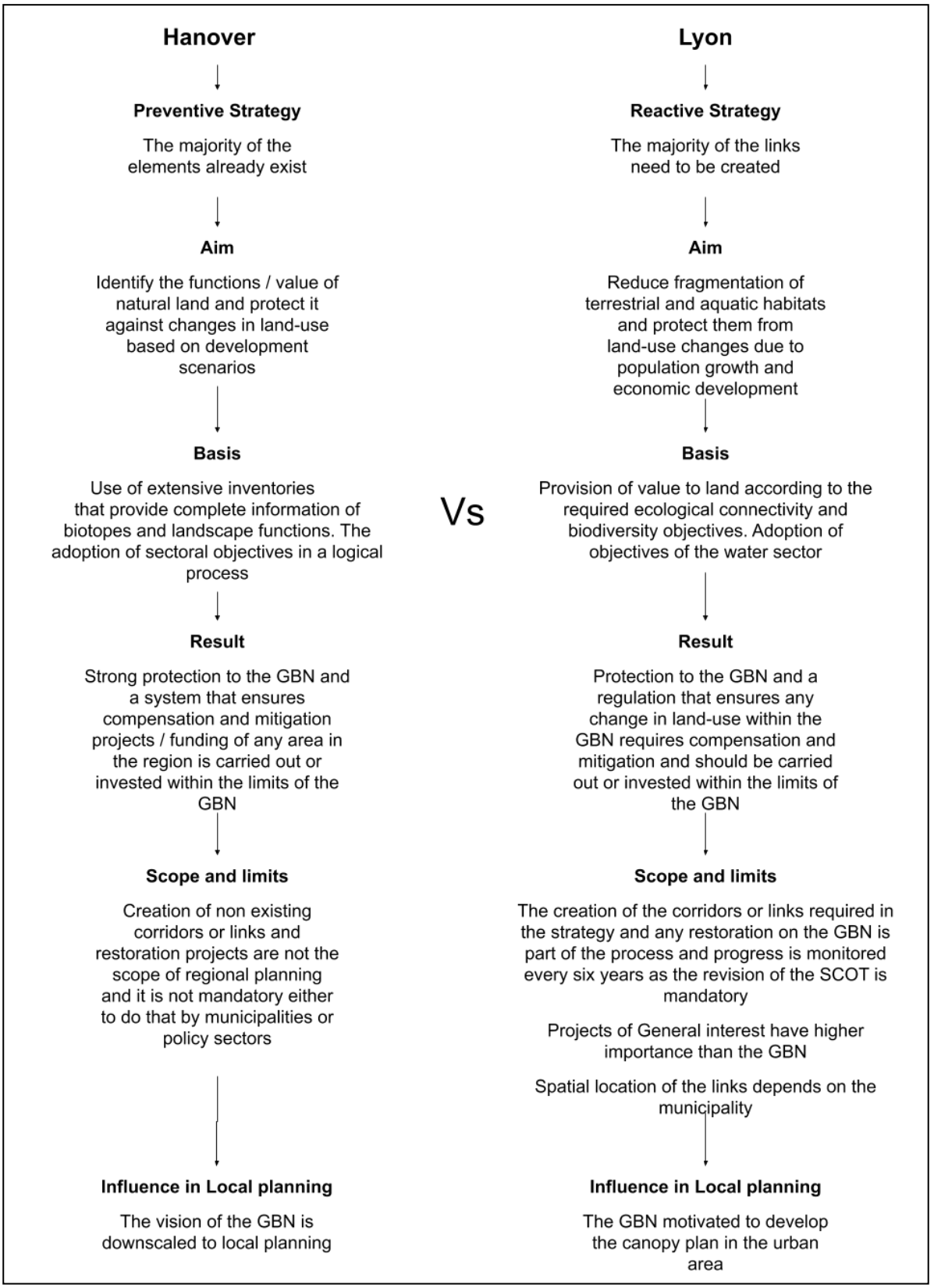


Fig 7. Comparison scheme for the Green and Blue Network in the metropolitan area of Lyon and the Region of Hannover.

Chapter 4: Conclusions and lessons

- The analysis of the two cases studies showed that the implementation of the spatial planning tool green and blue network allows territories to achieve sustainable development by protecting about 50% of their natural areas and ensuring ecological connectivity between biodiversity hubs, and it is independent of the planning system of the region. Thus, it could be and should be implemented worldwide.

- The use of a solid concept behind the green and blue network strategy, such as the landscape functions or the ecosystem services, facilitates the valorization of natural areas and strengthens the justification for their protection under stricter regulations.

- A reactive type of strategy requires more political will and funding to accomplish the full implementation of the regional strategy. These challenges could be attenuated by putting in place monitoring systems, strengthening communication and relationships with local planning, and the adoption of a solid concept supporting the strategy.

- The concept of ecosystem services (ES), although useful to implement the GBN or to understand the logic behind the landscape planning system, which uses the concept of landscape functions, is not explicitly mentioned nor adopted by spatial regional planners and thus ES remains as a theoretical concept. This is interesting after recalling that the definition of landscape functions used in landscape planning overlaps with the definition of ecosystem services, yet, the concept of landscape functions “emphasises the role of underlying values and the depiction of the spatial reality under stronger selection criteria concerning the underlying societal demands” (Von Hareen and Albert, 2011) which sheds light on the flaws of the ES concept and facilitates its application into spatial planning when taking into consideration those differences. Nonetheless, “in areas located closer to the urbanized zone the identification of functions related to natural ecosystems reduced their importance and services related to human activities acquire more value and become the tool to protect those areas from the pressures of the urbanization” (P. Mary, personal communication, 4th April 2019).

- The requirements to develop the GBN are:
    - The biodiversity inventories such as Natura 2000 and a strict work from the Water Directive in the identification of important areas for water management. These two are catalyst and key drivers for the development of the Green and Blue Network strategy.
    - The role of NGOs or environmental institutions, such as the Greenelle in France and the Federal Agency for Nature conservation in Germany. They were key to envision and to establish the strategy.

- The educational component of the concept of landscape functions makes easier its adoption by landscape and urban planners. Having learned the concept at university no only ensures they will use the concept but also facilitates communication between sectoral departments where spatial planning is integrated.

- Synergies between policy sectors is the common and effective source of funding for GBN implementation. Thus, it is important to set up clearly the services or functions of the elements of the GBN.

- The GBN shows the importance to protect terrestrial and aquatic ecosystems against different threats, this facilitates binding spatial planning with climate change mitigation and adaptation objectives.

- It is important to seek for a regional or metropolitan approach. As evidenced in both case studies, the majority of natural assets are not in the core of the city but in its FUA or peri urban area, this requires the communication and cooperation of different municipalities; thus, municipal planning does not provide the adequate scale to implement a GI strategy that leads to sustainable development. The transition towards a territorial governance scheme that resembles the regional or metropolitan governance (as the ones from the two case studies) is fundamental to implement the GBN strategy.

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ANNEX

Administrative Structure of UrbaLyon

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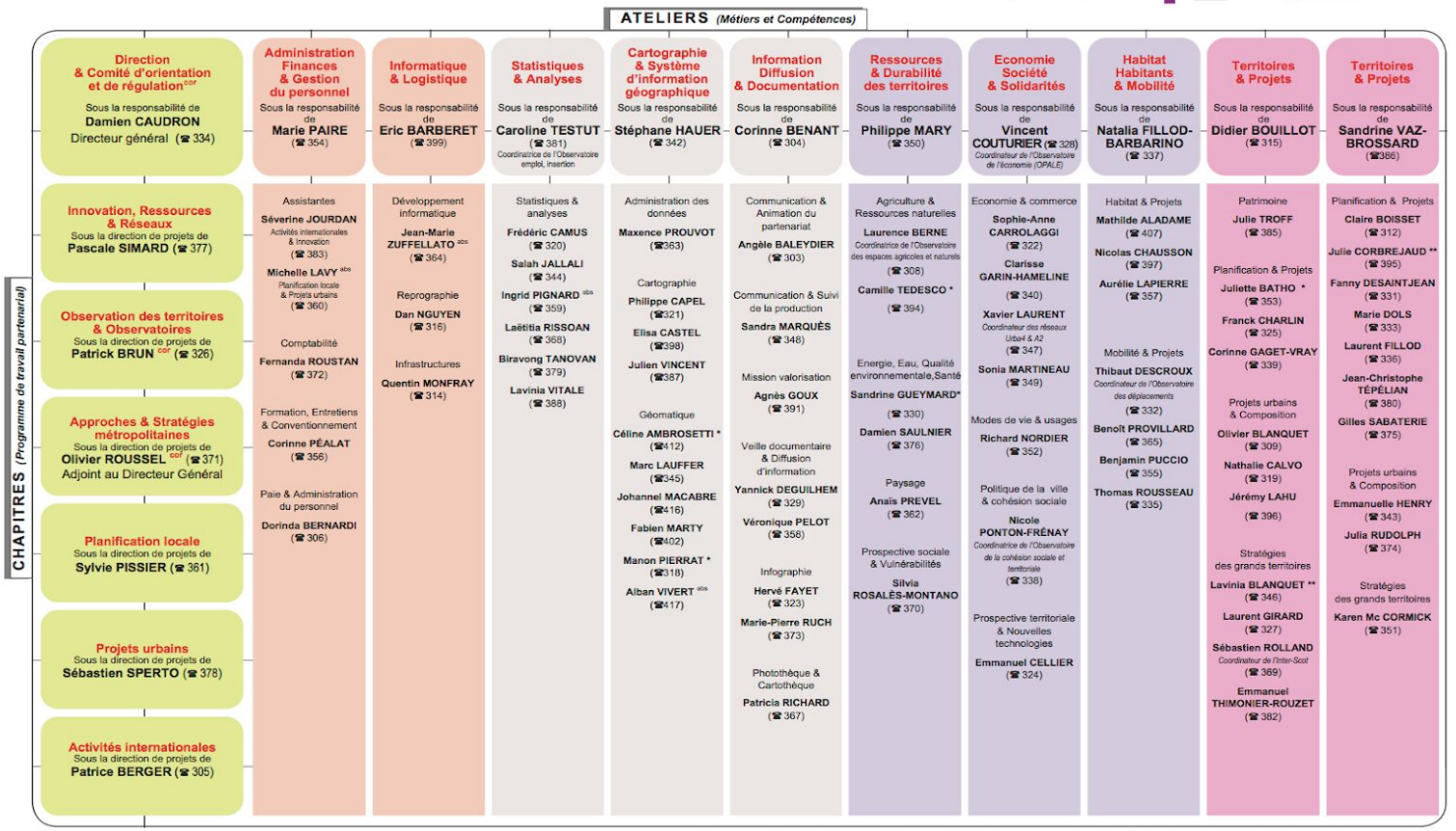

* *CDD*
** *Contrats de professionnalisation, d'apprentissage et de recherche*
abs *Absence de longue durée*
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