

Uptake of the green infrastructure concept in urban policies and planning: a field study in 4 European cities¹

Michael Leone¹, Ieva Misiune², Luís Valença Pinto^{2,3}, Julia Palliwoda⁴, Raïsa Carmen¹, Sander Jacobs^{1,5}, Jörg A. Priess⁴

¹ Research Group Nature and Society, Research Institute for Nature and Forest INBO, Havenlaan 88 bus 73, 1000 Brussels, Belgium

² Environmental Management Laboratory Mykolas Romeris University, Vilnius, Lithuania

³ Research Centre for Natural Resources, Environment and Society (CERNAS), Polytechnic Institute of Coimbra, Escola Superior Agrária de Coimbra, Coimbra, Portugal

⁴ Helmholtz-Center for Environmental Research - UFZ Department for Computational Landscape Ecology
Permoserstraße 15, D-04318 Leipzig

⁵ Belgian Biodiversity Platform BBPF, Avenue Louise 231, 1050 Brussels, Belgium

Abstract

With the prospects of urban population continuing to grow and demands for more liveable, healthy and resilient cities, green infrastructure increasingly emerged over the last decade as a strategy within the EU to improve the quality of life in urban areas as it can deliver ecological, socio-cultural and economic benefits. To reach the EU's political ambitions, it is vital that the local scale takes up the same concept. To plan green infrastructure that provides wanted benefits it is essential to integrate local values - including environmental justice values - and sustainability targets. We investigate how the green infrastructure concept is taken up in policies relevant for urban green space and which values shape green infrastructure in these policies. A document analysis was conducted in four European cities. Additionally, interviews were conducted to investigate what interactions municipalities have with other agencies - as possible ways for the concept green infrastructure to circulate - that may influence urban green space policies. While the concept can be found in every case study, its uptake and interpretation differ. We discuss the presence of established and new environmental concepts which influences uptake and the moldability of the green infrastructure concept, leading to different interpretations. Moreover, to spread a concept to local applications driving forces are required to incentivize the concepts (re-)use in order to make it recognized and shared.

Keywords: urban green infrastructure, multifunctionality, environmental justice, urban green space policies, policy analysis

¹ To be submitted to [Journal of Environmental Policy & Planning](#)

1. Introduction

Over half of the world's population lives in urban territories raising an enormous pressure on natural environments through urban sprawl, pollution and environmental degradation (United Nations, 2018). Since the urban population is projected to continue to grow, an increase of these pressures can be expected, as well as demands for more liveable, healthy and resilient cities (Elmqvist et al., 2015). One of the key strategies to mitigate the impacts of urbanisation and improve the quality of life in urban areas is the implementation of green infrastructure (Benedict and McMahon, 2006; Natural England and Landuse Consultants, 2009; European Commission, 2013). Green infrastructure is recognized as “*a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services*” (European Commission, 2013: 3) and includes in urban areas i.a. parks, forests, allotment gardens, vacant lots and water bodies. Furthermore, green infrastructure can be a nature-based and cost-effective alternative to conventional ‘grey’ solutions to address emerging urban issues such as increasing heat stress, air filtration, water retention, water hazards, carbon storage, greywater treatment, restoring degraded land and ecosystems (Jato-Espino et al., 2018; Calfapietra and Cherubini, 2019; Kalantari et al., 2019; Martín et al., 2020a; Martín et al., 2020b). Previous research acknowledges multifunctionality and connectivity as core functional characteristics of green infrastructure (Hansen and Paulet, 2014; Wang and Banzhaf, 2018; GRETA project, 2018; Girma et al., 2019; Hansen et al., 2019). Green infrastructure can provide multiple or cross-cutting ecological, social and economical benefits by means of benefits to nature (e.g. supporting biodiversity through i.a. connecting natural areas), provision of different ecosystem services or nature's contribution to people (e.g. regulation of local climate, regulation of fresh water, possibilities for recreation) and quality of life benefits (e.g. improved public health, more attractive cities, creation of jobs) (Hansen and Pauleit, 2014; Hansen et al. 2016; Pakzad and Osmond, 2016). The idea of multifunctionality is that one green infrastructure element or structure has the ability to provide several benefits, which often come in bundles and can be mutually reinforcing (Natural England and Landuse Consultants, 2009; Mazza et al., 2011; Liqueste et al., 2015; Wang and Banzhaf, 2018; GRETA project, 2018).

Decision making, implementation and management of green spaces is shaped by different sets of values of nature (Jacobs et al., 2016, Villegas-Palacio et al, 2016). Mapping diverse values of green infrastructure users and other stakeholders allows for choices to be made on what set of (ecosystem) services it offers, how green infrastructure is designed and managed and where it is

located through i.a. balancing demands, values and norms and considering trade-offs (Turlerboom et al., 2018; Paulin et al., 2020). Jacobs et al. (2016) highlight “*the urgency and importance to integrate nature's diverse values in decisions and actions*”. However, values to green infrastructure go beyond the provision of mere benefits to nature and humans. They may include ethical and rational values such as accessible and respectful decision making to peoples’ living environment and fair access and equal distribution for all said benefits (Aragão et al. 2016; Rigo and Németh, 2018; Nesbitt et al., 2019; Zhu et al., 2019). The urban context - in which multiple cultural and ethnic groups (with different worldviews) live within a varying range of socio-economic circumstances and in a densely populated (and limited) space - makes these considerations even more relevant: which benefits are needed and wanted and who profits? Not only intrinsic and instrumental benefits should shape the decisions of location, design and management of UGI but values related to governance and environmental justice aspects need to be included to achieve desired social and environmental synergies.

The concept of green infrastructure emerged in EU policy within the Biodiversity Strategy 2020 as a part of the strategy to maintain and enhance ecosystems and their services (target 2 (European Commission, 2011)). As part of this political ambition, the European Commission (EC) published a green infrastructure strategy in 2013 in which the importance of green infrastructure for urban areas is emphasized (European Commission, 2013). The EC aims to promote and ensure the development of green infrastructure in spatial and land-use planning through integration into existing EU’s sectoral legal, policy and financial instruments (European Commission, 2013). In order to reach the EU’s political ambitions, it is vital that the concept is taken up by the member states in national, regional and local policies (besides EU’s instruments) in order to mobilize these scales for urban green infrastructure implementation.

Few recent studies analysed how green infrastructure is integrated in urban spatial planning, i.a. on green infrastructure and ecosystem service integration into national and municipal level documents in Finland (Di Marino et al. 2019), presence of green infrastructure and nature-based solutions in the city of Poznań, Poland (Zwierzchowska et al. 2019), or specifically green infrastructure integration into regional or national strategic spatial plans (Thomas and Littlewood 2010; Mell et al., 2017). No studies are available combining analyses on green infrastructure uptake in policy combined with an assessment of values associated with green infrastructure planning.

The aim of this paper is to investigate the policy uptake of the green infrastructure concept for urban planning and gain an understanding (in terms of values) whether these policies contribute to the planning of multifunctional and just urban green infrastructure. To do so, a multi-scale (national to local) policy document analysis in four cities across Europe was conducted. Furthermore, for a concept to be taken up in policy, it has to be circulated and used into new (policy) arenas (van Herzele et al. 2019). Therefore, at least one public servant responsible for green public spaces in each city was interviewed to gain a preliminary insight into what interactions - possible ways for the concept green infrastructure to circulate - between different agencies are present to bring new ideas and concepts into municipal policies. We conclude the paper with a discussion on the uptake of green infrastructure in reality where policies and policy makers are applying already established ideas and concepts, and the (1) importance of recirculating and (2) moulding the concept.

2. Methodology

2.1 Case studies description

The research was conducted as a part of the UrbanGaia project, which seeks to develop a realistic indicator framework to evaluate, manage and develop (performant) for urban green infrastructure based on 4 diversified case study (CS) cities in Europe: Coimbra in Portugal, Genk in Belgium, Leipzig in Germany and Vilnius in Lithuania (Fig. 1). The cities were selected to cover a broad range of socio-ecological and governance contexts in Europe. Different geographical locations and climate, the types of green infrastructure as well as legal and governance settings support the explorative analyses and identification of common or specific patterns.

Coimbra (Portugal, Mediterranean climate) is the biggest city in the Portuguese Centro Region, which doubled its population in 70 years, up to 2001, when it started losing population, following the national trend. Its medieval centre is surrounded by several areas of expansion, accompanied by a variety of green infrastructure representing the preferences of different generations for leisure, recreation and relations to nature, including one of the oldest Botanical Gardens worldwide. Coimbra's green infrastructure includes riverbank ecosystems, different types of gardens, areas specifically assigned for urban agriculture, and urban forests.

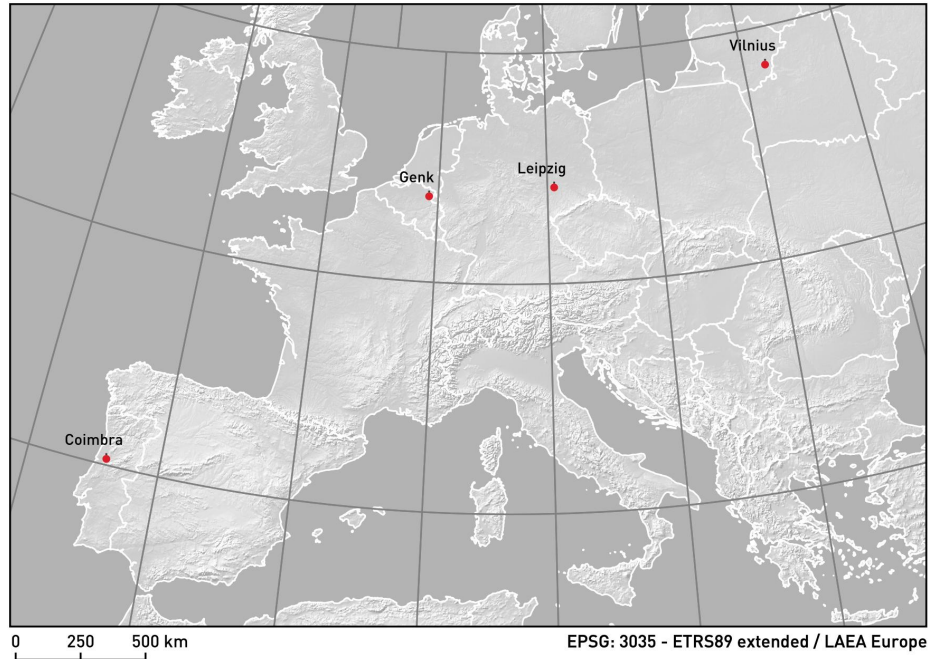


Figure 1. Map with the location of the 4 CS

Genk (Belgium, temperate maritime climate) is located in the east of Flanders (state) in the province of Limburg. Due to its mining sites and presence of Ford Motor Company (factory closed in 2014) Genk grew exponentially over the last century and became an industrial center of the province and is still growing. Genk is a strongly urbanized, fragmented city with many areas dominated by grey infrastructure. As a consequence of its industrial past, Genk is one of the most culturally diverse cities in Flanders. Since the closure of the mining industry (in 1987) and the greening of these areas, Genk has become one of the greenest cities of Flanders. Genk's green infrastructure includes a stream valley crossing the city, parks, allotment gardens, among others.

Leipzig (Germany, humid continental climate) is located in the Federal State of Saxony in the eastern part of Germany and currently the fastest growing city in Germany with a growth rate of about 2% per year (Stadt Leipzig, 2019). Its urban structure is characterised by an inner residential ring of Wilhelminian housing estates around the city centre. The current strategic planning in Leipzig aims at the compact city including redensification to avoid urban sprawl and the simultaneous development of urban green areas. The Weisse Elster river and other minor rivers flow through the city partly accompanied by Riparian forests, intersecting the city from S to NW. Leipzig is also characterised by diverse green spaces, about 14% of the 300 km² of city area being covered by forests and parks.

Vilnius (Lithuania, humid continental climate) is the only growing city in the country. It's historic centre is a UNESCO world heritage site. Despite an increasing urban sprawl, especially in the postsocialist period, large parts of the city (over 60% of the territory) are covered by green areas. Urban GI such as urban parks, including riverine forests, provide a wide range of services to citizens and visitors. Important is that over 17% of the territory is protected areas, consisting of regional parks, state and municipal reserves, and natural heritage sites.

Table 1. Description of the four cities.

City	National administrative structure	Total area (km ²)	Public green space (km ²)	Population (thousands)
Coimbra, Portugal	Unitary semi-presidential republic, with districts (regions) divided into municipalities.	51	2,03	92 (2018)
Genk, Belgium	Federal parliamentary with regions (state), provinces and municipalities.	88	37,73	66 (2019)
Leipzig, Germany	Federal parliamentary republic, with federal states and districts (regions) at municipal level.	297	41,60	601 (2019)
Vilnius, Lithuania	Unitary semi-presidential republic, with counties, divided into municipalities.	401	247	547 (2019)

2.2 Content analysis of strategic and legal documents and land use plans

Analyses of a concept uptake within policy making and planning practices mainly follow two approaches: either investigating the perceptions of stakeholders, or reviewing relevant documents (Cortinovis and Geneletti, 2018). A comprehensive document analysis was the main approach for this research, however within each city at least one local public servant responsible for green public space was interviewed to provide insights on which interactions were of influence for policy making or planning practices. For the document analysis, a protocol was developed to perform a content analysis of national, state, regional and local policies (dependent per city, see table 1) and strategies relevant for the urban planning and implementation of green infrastructure in each CS. The protocol consisted of 3 parts to guide the analysis.

The first part of the protocol aimed to identify the relevant policy, legislation and planning documents in relation to the urban planning and implementation of green infrastructure in each CS. Based on stakeholder knowledge, online search and snowballing, relevant documents were retrieved from official governmental websites or received directly from public servants. The search was not restricted to certain policy fields. The policy fields in which relevant documents were

identified can be found in table 2, part 1. Specifically, laws/decrees, norms, strategic documents, planning documents and good practices guides for/from public agencies were included in the document selection (table 2, part 1 defines the type of documents further). Policy documents published until the end of 2019 were included in the search and needed to be relevant for the current and near future (< 5 years from 2019) for urban planning and implementation of green infrastructure. For a document to be selected for further analysis it needed to (1) contain the concept of green infrastructure or a concept similar to green infrastructure and contain the multifunctionality and/or connectivity characteristic and (2) be relevant for urban planning. Considering the diversity of terms used to refer to green infrastructure, the documents were read after an initial keyword-search analysis ([Annex A](#)), to ensure that the analysis captured the diversity of terms associated with green infrastructure. Data on implementation year, policy field, type of document, implementation level and responsible authority was collected for each relevant document (table 2, part 1). Subsequently, a descriptive analysis was conducted on how the identified policy documents function in relation to each other.

The second part of the protocol identified the uptake and relevance of the green infrastructure concept in the relevant documents. We assessed if the GI concept was directly or indirectly mentioned and estimated its relevance to the problematic situation it can respond to on a three-scale level (table 2, part 2).

The third part aimed to assess which values are associated with green infrastructure in the relevant policy and planning documents for each city. UrbanGaia developed an analytical framework based on the plural valuation framework of nature human-relationships as applied in IPBES (Díaz *et al* 2015), and adapted to an European green infrastructure context (table 3, see also Carmen *et al*. 2020). A nominal scale (table 2, part 3) was applied to score the level of consideration of each value. One score was given to each value for each governance level in order to investigate if there were different foci - different values associated with green infrastructure - at different levels (national to local). Each score got accompanied by a description why that score was given with reference to the relevant document. Regular discussions among the researchers ensured that the scoring was done in a similar way.

Table 2. Data collection of policy documents

Scoring attribute	Explanation
Part 1: Identification	
Implementation year	
Policy field	Land use planning Nature protection Climate change Forestry Sustainable development
Type of document	Law/Decree: legislation, sets out the rules of what can and cannot be done Norm: document explaining and defining the concrete norms that are needed to implement the requirements of a specific law Strategic document: sets out a vision for the (near) future with aims/objectives/goals Planning document: defines and plans actions (to reach set goals)
Issued at governance level	National State Province / Regional Municipal / Local
Responsible entity	Entity responsible for implementing or enforcing the identified document
Part 2: Uptake and relevance of urban green infrastructure	
Direct or indirect mention of green infrastructure	Direct mention: specific terms are used in the document such as (urban) green(-blue) infrastructure, or a closely related term, in relation to urban areas and consists of both the connectivity and the multifunctionality characteristics. Indirect mention: specific terms ((urban) green(-blue) infrastructure) are not used, but the document mentions terms that capture similar ideas as green infrastructure in an urban setting and has either the connectivity or the multifunctionality characteristic (or both).
Green infrastructure defined	Yes: The policy document defines its understanding of green infrastructure. No: The policy document doesn't give a definition for the concept, even when the green infrastructure concept is used explicitly.
Relevance	High relevance: Green infrastructure is presented as an essential component or as a main solution of the urban issues presented (to which green infrastructure can provide a solution) in the policy document. Medium relevance: Green infrastructure plays a moderate part in the solution of the urban issues presented (to which green infrastructure can provide a solution) in the policy document. Low relevance: Green infrastructure has only a minor role in the solution of the urban issues presented (to which green infrastructure can provide a solution) in the policy document.
Part 3: Values	
Values shaping policy	4 - Very high consideration: the value - in relation to green infrastructure - is presented as e.g. a goal or a chapter title and has multiple actions related to it, in at least one of the relevant documents. 3 - High consideration: the value - in relation to green infrastructure - is presented as e.g. a sub-goal or a subchapter and has one or multiple actions related to it, in at least one of the relevant documents. 2 - Medium consideration: the value - in relation to green infrastructure - is addressed (extensively) in the text and/or an action related to the value without the value being presented as a (sub-)goal. 1 - Low consideration: the value - in relation to green infrastructure - is addressed in text only to a limited extent without much elaboration. 0 - No consideration: the value - in relation to green infrastructure - is not explicitly addressed or mentioned.

Table 3. Analytical framework for document analysis (adapted from IPBES framework).

Value category	Dimension	Value	Explanation
Intrinsic values	Nature	Maintaining and strengthening nature and biodiversity	The maintenance or strengthening of nature or ecological quality. This can refer to maintaining or strengthening individual organisms, biophysical assemblages, biophysical processes or biodiversity.
		Quantity and quality of UGI	The design of UGI in terms of its quantity and quality. Aspects related to the quantity of UGI can be hectares of urban green space or amount of green space per capita. Quality can refer to ecological quality, in function of human utilization and benefits, or the quality of the design of UGI such as connectivity (e.g. walking/cycling paths), accessibility (e.g. opening hours, fences, gates), facilities (e.g. benches, picnic areas, sport areas) and the location.
Instrumental values	Contributions	Regulation services	Beneficial nature contributions to people obtained from the regulation of ecosystem processes, such as regulation of air quality, climate, freshwater quantity, flow and timing, etc.
		Material contributions	Provision of materials from ecosystems, such as food, water, timber, etc.
		Non-material contributions	The (non-material) physical and psychological experiences that nature provides, such as recreational experiences. This includes experiences that stimulate learning and inspiration. Furthermore, non-material contributions also include the supporting role of nature to identities of regions, cities, neighborhoods or social groups.
		Cultural relations	Cultural relations include aspects such as heritage (historical elements), sense of place (meeting place for (sub)communities, organization of events) and stewardship (nature management activities by citizens, adopted trees).
		Health & wellbeing aspects	Health & wellbeing includes aspects such as physical health, mental health, safety, social relations and education and knowledge.
Relational values	People	Economic aspects	The effects of surrounding U-GBI on the local economy such as attractiveness to new businesses, tourism, (new) inhabitants and new jobs created related to green.
		Governance aspects	This category focuses on decision-making and implementation processes of urban GI. Relevant aspects related to urban GI governance are inclusion of stakeholders, aiming multifunctionality to achieve multiple objectives, etc.
		Justice aspects	This category focuses on two justice aspects namely procedural justice (inclusion of vulnerable groups in governance) and distributional justice (fair social and spatial division of UGI).

Lastly, in each city one or two public servants responsible for green public spaces were interviewed (6 total) about what interactions between different agencies are (structurally) present to bring new ideas and concepts into municipal policies and whether these interactions influenced the uptake of the green infrastructure concept. The interviewees were asked about the presence of i.a. municipal networks where approaches and concepts are discussed, collaboration with research institutes that bring in knowledge on new concepts or literature that can inspire approaches to green public spaces. Furthermore, the interviewees were questioned about what difficulties or obstacles they

experienced when operationalizing the green infrastructure concept into municipal policies. The interview questions can be found in [Annex B](#).

All data was cleaned and visualised in R using the *tidyverse*, *cowplot* and *ggplot2* packages.

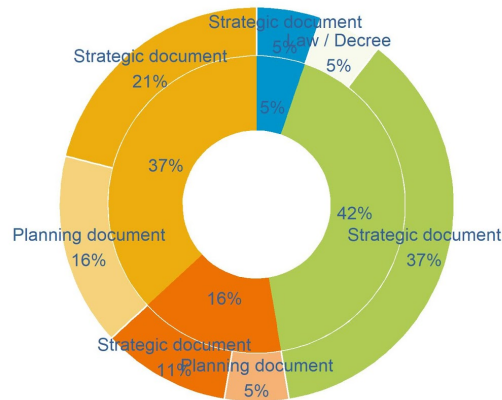
3. Results

3.1 Selected documents

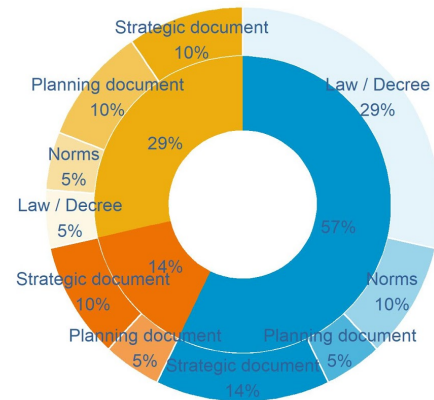
Documents which mentioned green infrastructure directly, or indirectly by using a concept similar to green infrastructure (that contained the multifunctionality or connectivity characteristic of green space), and are relevant for urban planning were selected for further analysis. The donut charts in figure 2 shows the type of relevant documents issued (outer donut) and at which governance level (inner donut) for each of the CS. The figure shows a few similarities and differences between the four CS. Firstly, in each CS we found most relevant documents at national level followed by the urban level, except for the Belgian CS where most relevant documents were found at state level followed by the urban level. Actually, this result is still in line with the other CS as the Belgian states (Flanders, Wallonia, Brussels) are responsible for spatial planning of its territories rather than the federal government. Secondly, the relevant documents of Coimbra CS and Vilnius CS contain more decrees and norms compared to Genk CS and Leipzig CS which contain more strategic documents. Less relevant planning documents have been found compared to strategic documents. Logically, most planning documents have been found at local level.

Next to governance level and type of document, we also recorded information on the area of interest. Accumulated across CS, a majority of the relevant documents were from the land-use planning policy field (68%), followed by nature protection (18%), climate change (8%), sustainable development (4%) and forestry (2%). A complete list of identified documents can be found in [Annex C](#).

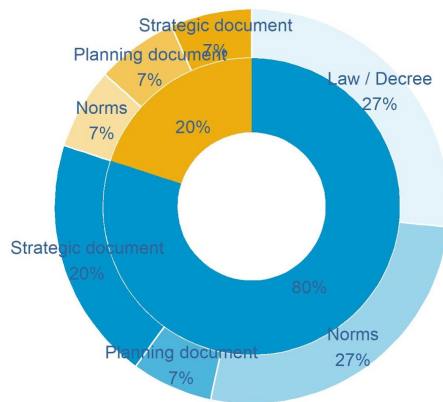
Genk, BE, 19 documents



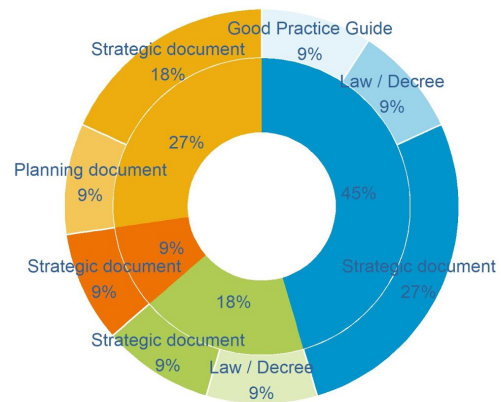
Coimbra, PT, 21 documents



Vilnius, LT, 15 documents



Leipzig, DE, 11 documents



Governance level: National (blue), State (green), Regional (orange), Local (yellow)

Figure 2: Governance level and type of document

3.2 Uptake of green infrastructure over time

A change of concepts and interpretations can be observed over time. In our analysis, we distinguish documents from before the release of EC green infrastructure strategy (2013) and after. Before 2013, the term ‘Green Infrastructure’ was not found in policy documents, but rather terms such as ‘Ecological Corridors’ and ‘Urban Natural Elements’ in Belgium, ‘Green Spaces for Collective Use’ and ‘Municipal Ecological Structure’ in Portugal, ‘Green connections’ in Germany, or ‘Nature Frame’ and ‘Green corridors’ in Lithuania. All these concepts lack either the multifunctionality or the connectivity aspects which are embedded in the EC definition of green

infrastructure. When the multifunctionality characteristic was lacking, the concepts had a strong focus on the ecological benefits of connecting natural areas.

From 2013 onwards there is an increasing use of the term green infrastructure or similarly framed concepts which contain both the multifunctionality and connectivity characteristic in policy documents (figure 3). Concepts evolved in their naming and understanding. In the Leipzig CS, relevant documents used the term of (Urban) Green and Blue Infrastructure. In the Genk CS, the term ‘(interlacing) network of green and blue’ was often used. Both in the Genk and Leipzig CS, their relevant concepts are defined as a(n) (urban) green (and blue) network that provides multiple benefits, thus containing the multifunctionality and connectivity characteristic. In Vilnius, the concept of ‘Nature Frame’ is still used, which over time started to include some other functions besides the ecological functioning of the concept. Besides, two policy documents do directly use the term green infrastructure, but both with a different understanding (1. Measures to improve the current state of the local ecological status, 2. A hierarchical system of (urban) green areas). Most relevant to urban green infrastructure is the concept of Greenery systems, which are man-made green areas and contain elements of connectivity (connecting urban areas, urban greenery, forests within and outside the city) and multifunctionality (support ecological stability, improve living and working environment, tourism). In Coimbra, the GI concept is mentioned but not defined in the policy documents, despite the high relevance given to the concept at the national level, where it is equated to grey infrastructures such as communications or transport. At the local level, the concept of Municipal Ecological Structure is still in use, mainly focused on nature connectivity and on the protection of natural and cultural landscapes, based on the old concept of the National Ecological Reserve, originally set in 1983. A detailed descriptive analysis on how GI is appearing and implemented in each CS can be found in [Annex D](#).

Besides a change in understanding, in the more recent policy documents the concept has also become more relevant as a solution to issues which green infrastructure can answer to (figure 3). The general trend of figure 3 could also be observed in each of the cases separately.

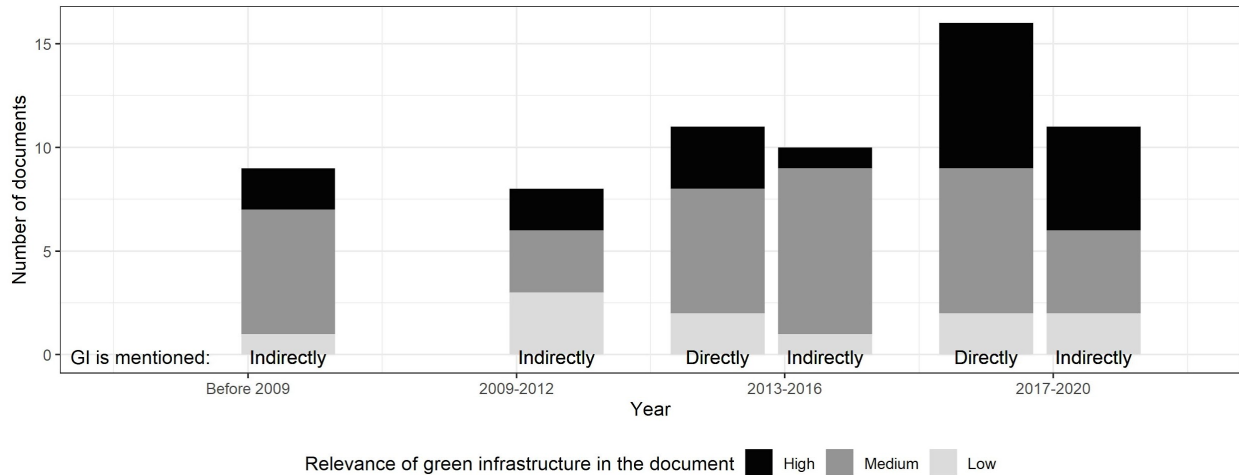


Figure 3: Indirect and direct use of the green infrastructure concept over the years (1995-2019) and the relevance of the concept in the documents, to urban issues to which green infrastructure can provide a solution. The greyscale of the stacked bars reflects the relevance of green infrastructure in the document.

3.3 Values associated with green infrastructure

Each CS gave a score to indicate how much the documents, at each governance level, consider the value types (0 to 4, see section 3 of Table 2). Figure 4 shows the median scores over all governance levels. Generally, the nature dimension is associated strongest with green infrastructure, especially values related to “Maintaining and strengthening nature and biodiversity”. Values related to regulation functions, non-material contributions and governance aspects are also well associated with green infrastructure. However, values related to material contributions, cultural relations, economic aspects and justice aspects are far less considered across CS.

Differences across CS can be noted. For example, Leipzig CS values the nature dimension and the contributing dimension higher than the people dimension, while in Coimbra CS the contributing dimension is valued highest, followed by the nature dimension, and lastly the people dimension. For Vilnius and Genk CS the nature dimension is valued most, but values are scattered over the contribution and people dimension. Furthermore, it is noticeable/compelling/eye-catching that Genk CS did not cover justice values while governance values are strongly considered (planning and implementing green infrastructure through an area-specific and integrated approach without explicitly mentioning justice considerations). Secondly, Vilnius CS did not have values related to material NCP and economic effects and regulation functions are less associated with green infrastructure compared to the other CS. Thirdly, in Coimbra there was no consideration of cultural values within green infrastructure at regional or local levels, only at national level, and values

related to governance are less associated with green infrastructure compared to other CS. Last but not least, Leipzig CS is the only one in which all values appeared in the policy documents.

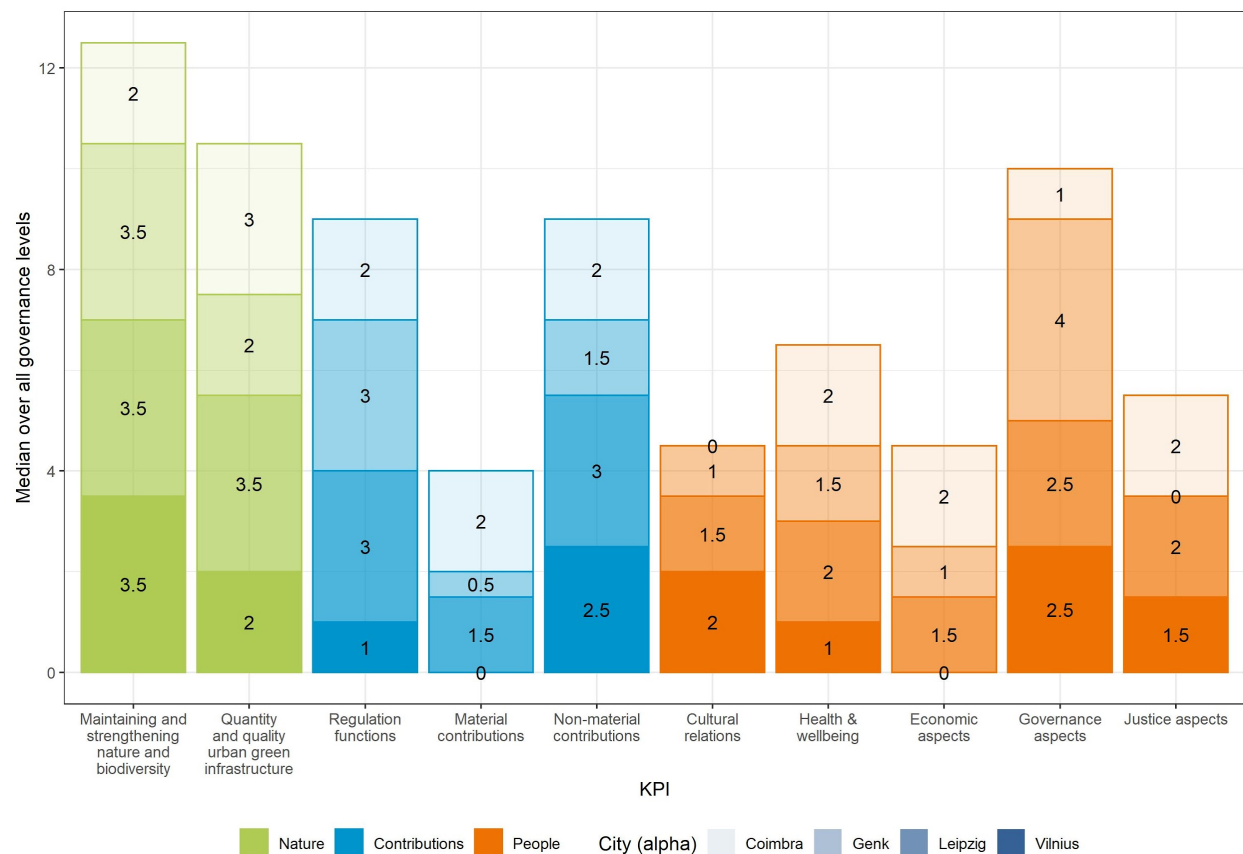


Figure 4: median score of all governance levels for each value.

3.4 Interactions influencing urban green space policy

The interviews highlight that the cities are involved in various interactions with different agencies for exchanging information and knowledge for urban green spaces. For example, Vilnius has close cooperation with national policy makers for their urban green spaces, Genk pro-actively searches for collaboration with research institutes to bring in new ideas, Coimbra has an example of how civil organisations influenced urban green spaces, and Leipzig has regular exchange with green space administrations from other cities. [Annex E](#) summarizes the presence and absence of different interactions for each city. Besides these interactions, the interviews highlighted that for bringing in new ideas and concepts it is important to have staff that has a personal interest in exploring (innovative) new approaches and a will to challenge established approaches or routines. For example, the Director of the Public Space Department in Coimbra is interested in green infrastructure related themes and searches for synergies to implement them and, in Genk, the

mayor strongly endorses - and encourages innovative solutions in one particular green infrastructure project and the green space department engages itself in new ideas and aims to implement them.

On the contrary, one of the challenges for operationalizing the green infrastructure concept in policy and planning was that it can be difficult to replace established ways of working due to scepticism towards the new concepts within the department. Other identified challenges are the limited staff within the municipality to work on the topic, the little available space for conceptual thinking as the focus is often on executing plans, and lack of finance for green infrastructure projects.

4. Discussion

The green infrastructure concept got grounded in EU policy through its uptake in the Biodiversity Strategy 2020 (European Commission, 2011) and the following Green Infrastructure Strategy (European Commission, 2013). In order to achieve the reality the EU green infrastructure strategy describes, the concept and its interpretations need to trickle down towards local planning and implementation. Our exploration highlights a varied uptake of the concept in national, state, regional and local policies relevant to four EU cities in different countries.

4.1 Green Infrastructure is a popular concept, but so are others - On the concept's uptake

As van Herzele et al. (2019) noted, new environmental concepts do not enter a blank world, but rather a world of already established concepts and practices embedded in policies. Some of these preceding - already established - concepts were found back in current policy (until the end of 2019). Terminology of these preceding concepts varied widely across countries but contained either a connectivity characteristic or a multifunctionality characteristic. Some of these concepts are about to be replaced (e.g. in Flanders, Belgium, the soon to be implemented Spatial Policy Plan uses a concept similar to green infrastructure, namely 'interlacing network of green and blue', while the current Spatial Structure Plan uses 'ecological infrastructure'), and in some cases policy-makers continue to use the established concepts (e.g. 'nature frame' and 'greeneries' in Lithuania, 'Municipal Ecological Structure' in Portugal).

Since the release of the EU strategy, the terminology of green infrastructure starts to appear within policy documents across countries. However, the interpretation differed: in Belgium and Germany the definitions are comparable to the EU definition, in Portugal the term is used but no clear definition was found, and in Lithuania the term was given a different interpretation (the

connectivity and multifunctionality characteristic not clearly expressed) as the established concepts remained leading within the policy documents. Mell et al. (2017) also found a varied uptake of green infrastructure when comparing its evolution in Germany and England and Di Marino et al. (2019) found a varied uptake within Finland. It requires time and commitment for environmental concepts such as green infrastructure to be taken up in policy and planning (Mell et al. 2017; Di Marino et al. 2019) which can be due to strong or inflexible established planning traditions (Laforteza et al. 2013; Lahde and Di Marino, 2019) and the hectic environment of spatial planning which is influenced by environmental, professional, cultural and political contexts (Di Marino et al. 2019).

Not only did we encounter variations in uptake between countries, but also between different policy levels within a country. For example, all strategic documents from 2013 at national, state and regional level in Genk CS mention the concept directly and are in line with the EU in terms of terminology and interpretation. Whereas, at local level the characteristics of the concept (connectivity and multifunctionality) are captured in their strategies and plans after 2013, but the concept itself is only mentioned in 2 of 4 of the relevant documents and never defined. The interview with the municipal public servant revealed that while connectivity and multifunctionality are indeed important cornerstones for their planning of green areas, they were more familiar with concepts such as ecosystem services and nature-based solutions.

Indeed, green infrastructure is not the only recent environmental concept trying to enter the policy arena; concepts such as ecosystem services and nature-based solutions are as well. While these concepts represent their own specialized way of looking at the environment and can be aligned to each other in a conceptual framework (Galan, 2020), in practice concepts coming from academia can be found complex and are adapted and simplified to the users' needs or practice (e.g. ecosystem services in van Herzele et al. 2019 and green infrastructure and ecosystem services in Di Marino et al. 2019). One concept can coexist and help realize the world of another concept (van Herzele et al. 2019), however there is a limit for concepts to be applied simultaneously within (local) policy making without increasing complexity or losing utility. Thus, new concepts need time to find their way in and challenge, replace or coexist with established concepts (Lahde and Di Marino, 2019; van Herzele et al. 2019) while also competing with other new concepts.

4.2 Locally adapted plural valuation or cherry picking - On flexibility resulting in varied values uptake

The variance in policy uptake goes together with the nature of the concept, namely, green infrastructure can be seen as a boundary concept. Also other studies discuss its broadness and elusiveness (Wang & Banzhaf, 2018; Hansen & Paulet, 2014) and its fluidity and pluralistic nature (Mell et al. 2017). Boundary concepts are loosely defined and their certain degree of abstractness allows it to be increasingly flexible. This flexibility allows such concepts to be molded to local contexts as there is space for multiple interpretations and to negotiate its content (Lowy, 1992; Allen, 2009) and to cope with complexity by reducing it into a simpler and manageable understanding suited for mainstream practice (van Herzele and Aarts, 2013).

Good as long as it stay within the described abstractness which in this case is the core characteristics. The core characteristics for green infrastructure are connectivity and multifunctionality, but within that space local adaption can vary widely in its function, especially when discussing multifunctionality. The nature dimension has been found an important value in all countries, but the implementation of other values related to the contributing and people dimension differed between countries. This is not surprising as natural elements are the concept's starting point and a selection of values can be molded as is deemed important for the local context. However, it is not known if the values found in policy documents reflect the values that are present in its society. Leaving out values may overlook the wellbeing of people who embrace these values (Jax et al. 2013). Results show a possibility/opportunity to mold even more?

While policy documents often consider governance aspects (how to develop local green infrastructure plans), considerations related to justice are less explicitly expressed in the same documents. Environmental justice should not be a value that is important only in certain contexts as people are always part of the equation within urban green infrastructure. To ensure a well-balanced and fair perspective in both policy making and planning, more attention to environmental justice should be given in policy documents and plans, to ensure equal distribution of benefits of green infrastructure. To reach this, justice aspects should be considered as a cornerstone besides connectivity and multifunctionality (Baró et al., 2019; Kronenberg et al., 2020; Langemeyer and Connolly, 2020).

While the flexibility of boundary concepts can allow adaptation to local context, there are also some risks related to it. Firstly, a concept can be molded in such a way to try to fit it within the established concepts and way of thinking that it transforms and loses its original understanding (van Herzele et al. 2019). For instance, there is still an ongoing discussion in Lithuania between

academics and policy makers if the national concept of "nature frame" has the same meaning as the European green infrastructure concept, while the policy documents indicate clear discrepancies between these two. Moreover, their actual use of the term "green infrastructure" has been molded into a different definition. Secondly, the abstractness requires action to mold the concept to local context, however this is often based on voluntary action, resulting in some agencies - or even individual departments inside an agency, as we have found during the interviews - picking up the concept and adopting it while others take a more hesitant approach. Lastly, due to the malleability each policy uptake or implementation can have its own interpretations resulting in different understandings existing simultaneously.

4.3 Natural selection or careful nurturing: factors determining uptake of a concept

New environmental concepts do not spread themselves to planning and practice. Vehicles are needed to bring the concept from academic theories to higher level policies and finally to local planning and implementation. A vehicle can be seen as an instrument to make the concept function and to make the concept trickle down to local planning and implementation. For green infrastructure we see the release of the biodiversity strategy 2020 and the green infrastructure strategy as one of the first vehicles to put the concept from academic theory to the policy agenda at EU level and its member states (Sources biodiversity strategy + GI strategy). However, a broad range of multiple vehicles are needed to bring it from the policy agenda towards wide-spread local policy, planning and implementation. Our interviews with municipal public servants give some insights on these vehicles to bring green infrastructure to their field of work and make the concept work. Such vehicles may include: written material such as (inter)national journals or handbooks that inspire planning and design of green infrastructure, participate in (inter)national or regional networks to exchange experiences and practices, participate in a research project that study and support the implementation of the concept on the ground and exchange knowledge. In Leipzig multiple vehicles bring green infrastructure to local policy and planning and is reflected in the high uptake of the concept in its policy. In Genk on the other hand there are fewer vehicles bringing green infrastructure into the policy agenda, which is reflected by a lower appearance of green infrastructure concept in local policy. However, other environmental concepts such as ecosystem services and nature-based solutions were brought in through research projects and resulted that the central green infrastructure characteristics multifunctionality and connectivity were still applied to their policy and planning. In Coimbra the GI concept is mainly being used at the planning level, which uses few and mostly informal vehicles, still lacking a clear local policy integration.

For a concept to be recognized and bring its ideas into existence, its discourse needs to be recirculated (Hook, 2001; van Herzele and Aarts, 2013) and through its use and re-use a concept is made into something that is common or shared (Butler, 2010). Such vehicles act as a tool to incentivize its use and re-use and multiple vehicles per geographical area are needed to embed the concept long term.

5. Conclusion

Not only the established concepts need to be challenged, but people working with them/routines of practice need to be challenged as well.

The GI concept leaves some kind of flexibility in its uptake in local, regional and national policies. The implementation of different values including multifunctionality and justice remains locally specific and is influenced by present local social values.

References

- Allen, D. (2009) From boundary concept to boundary object: The practice and politics of care pathway development, *Social Science & Medicine*, 69, p. 354-361.
- Aragão, A., Jacobs, S., Cliquet, A. (2016) What's law got to do with it? Why environmental justice is essential to ecosystem service valuation. *Ecosystem Services*, 22, 221-227.
- Austin, G., 2014. Stockholm: green infrastructure case study, *Green infrastructure for landscape planning. Integrating human and natural systems*, London & New York, pp. 217-245.
- Baró, F., Calderón-Argelich, A., Langemeyer, J. & Connolly, J.J.T. (2019) Under one canopy? Assessing the distributional environmental justice implications of street tree benefits in Barcelona. *Environmental Science & Policy*, 102, 54-64. <https://doi.org/10.1016/j.envsci.2019.08.016>.
- Benedict, M. A., McMahon, E. T. (2006) Green infrastructure: Linking landscapes and communities. *Urban Land* (Vol. June). *Washington, DC: Island Press*.
- Butler, J. (2010) Performative Agency. *Journal of Cultural Economy*, 3:2, 147-161, DOI: [10.1080/17530350.2010.494117](https://doi.org/10.1080/17530350.2010.494117)
- Calfapietra, C., Cherubini, L. (2019) Green Infrastructure: Nature-Based Solutions for sustainable and resilient cities. *Urban Forestry & Urban Greening*, 37, 1-2.
- Carmen, R., Jacobs, S., Leone, M., Palliwoda, J., Pinto, L., Misiune, I., Priess, J.A., Pereira, P., Wanner, S., Ferreira, C.S.S. (2020) Keep it real: selecting realistic sets of urban green space indicators. *Environmental Research Letters*, 15.
- Cortinovis, C., Geneletti, D. (2018) Ecosystem services in urban plans: What is there, and what is still needed for better decisions. *Land Use Policy*, 70, 298-312.
- Díaz, S., S. Demissew, J. Carabias, C. Joly, M. Lonsdale, N. Ash, A. Larigauderie, J.R. Adhikari, S. Arico, A. Baldi, A. Bartuska, I.A. Baste, A. Bilgin, E. Brondizio, K.M.A. Chan, V.E. Figueroa, A. Duraipappah, M. Fischer, R. Hill, T. Koetz, P. Leadley, P. Lyver, G.M. Mace, B. Martin-Lopez, M. Okumura, D. Pacheco, U. Pascual, E.S. Pérez, B. Reyers, E. Roth, O. Saito, R.J. Scholes, N. Sharma, H. Tallis, R. Thaman, R. Watson, T. Yahara, Z.A. Hamid, C. Akosim, Y. Al-Hafedh, R. Allahverdiyev, E. Amankwah, T.S. Asah, Z. Asfaw, G. Bartus, A.L. Brooks, J. Caillaux, G. Dalle, D. Darnaedi, A. Driver, G. Erpul, P. Escobar-Eyzaguirre, P. Failler, A.M.M. Fouda, B. Fu, H. Gundimeda, S. Hashimoto, F. Homer, S. Lavorel, G. Lichtenstein, W.A. Mala, W. Mandivenyi, P. Matczak, C. Mbizvo, M. Mehrdadi, J.P. Metzger, J.B. Mikissa, H. Moller, H.A. Mooney, P. Mumby, H. Nagendra, C. Nesshover, A.A. Oteng-Yeboah, G. Pataki, M. Roué, J. Rubis, M. Schultz, P. Smith, R. Sumaila, K. Takeuchi, S. Thomas, M. Verma, Y. Yeo-Chang, D. Zlatanova. 2015. The IPBES conceptual framework: Connecting nature and people. *Current Opinion in Environmental Sustainability*, 14, 1-16.
- Di Marino, M., Tiitu, M., Lapintie, K., Viinikka, A., Kopperoinen, L. (2019) Integrating green infrastructure and ecosystem services in land use planning. Results from two Finnish case studies. *Land Use Policy*, 82, 643-656.

EC - European Commission (2011) Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. COM(2011) 244 final, Brussels.

EC - European Commission (2013) Green Infrastructure (GI) — Enhancing Europe's Natural Capital. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM(2013) 249 final, Brussels.

Elmqvist, T., Setälä, H., Handel, S.N., van der Ploeg, S., Aronson, J., Blignaut, J.N., Gómez-Baggethun, E., Nowak, D.J., Kronenberg, J., de Groot, R. (2015) Benefits of restoring ecosystem services in urban areas. *Current Opinion in Environmental Sustainability*, 14, 101-108.

Galan, J. (2020) Towards A Relational Model for Emerging Urban Nature Concepts: A Practical Application and an External Assessment in Landscape Planning Education. *Sustainability*, 12, 2465. <https://doi.org/10.3390/su12062465>

Girma, Y., Terefe, H., Pauleit, S., Kindu, M. (2019) Urban green infrastructure planning in Ethiopia: The case of emerging towns of Oromia special zone surrounding Finfinne. *Journal of Urban Management*, 8, 75-88.

GRETA project- “GReen infrastructure: Enhancing biodiversity and ecosysTem services for territoriAl development”. Draft Final Synthesis Report. Version 20/11/2018.

Hansen, R. & Pauleit, S. (2014) From Multifunctionality to Multiple Ecosystem Services? A Conceptual Framework for Multifunctionality in GreenInfrastructure Planning for Urban Areas. *AMBIO*, 43, 516-529.

Hansen, R., Rolf, W., Santos, A., Luz, A.C., Száraz, L., Tosics, I., Vierikko, K., Rall, E., Davies, C., & Pauleit, S. (2016) Advanced urban green infrastructure planning and implementation. GREEN SURGE project Deliverable 5.2.

Hansen, R., Olafsson, A.S., van der Jagt, A.P.N., Rall, E., Pauleit, S. (2019) Planning multifunctional green infrastructure for compact cities: What is the state of practice? *Ecological Indicators*, 96, 99-110.

Hook D. (2001) Discourse, Knowledge, Materiality, History: Foucault and Discourse Analysis. *Theory & Psychology*, 11(4), 521-547. doi:[10.1177/0959354301114006](https://doi.org/10.1177/0959354301114006)

Jacobs, S., Dendoncker, N., Martín-López, B., Barton, D.N., Gomez-Baggethun, E., Boeraeve, F., McGrath, F.L., Vierikko, K., Geneletti, D., Sevecke, K.J., Pipart, N., Primmer, E., Mederly, P., Schmidt, S., Aragão, A., Baral, H.,

Bark, R.H., Briceno, T., Brogna, D., Cabral, P., De Vreese, R., Liqueste, C., Mueller, H., Peh, K.S.-H., Phelan, A., Rincón, A.R., Rogers, S.H., Turkelboom, F., Van Reeth, W., van Zanten, B.T., Wam, H.K. & Washbourne, C.-L. (2016) A new valuation school: Integrating diverse values of nature in resource and land use decisions. *Ecosystem Services*, 22, part B, 213-220.

Jato-Espino, D., Sañudo-Fontaneda, L.A. & Andrés-Valeri, V.C. (2018) Green Infrastructure: Cost-Effective Nature-Based Solutions for Safeguarding the Environment and Protecting Human Health and Well-Being. In: Hussain C. (eds) *Handbook of Environmental Materials Management*. Springer, Cham. Doi: https://doi.org/10.1007/978-3-319-58538-3_46-1

Jax, K., Barton, D.N., Chan, K.M., de Groot, R., Doyle, U., Eser, U., Görg, C., Gomez-

Baggethun, E., Griewald, Y. & Haber, W. (2013) Ecosystem services and ethics. *Ecological*

Economics, 93, 260–268.

Kalantari, Z., Ferreira, C. S. S., Deal, B., Destouni, G. (2019) Nature-based solutions for meeting environmental and socio-economic challenges in land management and development. *Land Degradation & Development*, 31, 1867-1870. Doi: <https://doi.org/10.1002/ldr.3264>

Kronenberg, J., Haase, A., Łaszkiwicz, E., Antal, A., Baravikova, A., Biernacka, M., Dushkova, D., Filčák, R., Haase, D., Ignatieva, M., Khmara, Y., Razvan Niță, M. & Onose, D.A. (2020) Environmental justice in the context of urban green space availability, accessibility, and attractiveness in postsocialist cities, *Cities*, 106. <https://doi.org/10.1016/j.cities.2020.102862>

Laforteza, R., Davies, C., Sanesi, G. & Konijnendijk, C.C. (2013) Green Infrastructure as a tool to support spatial planning in European urban regions. *iForest*, 6, 102-108. doi: 10.3832/ifor0723-006

Lähde, E. & Di Marino, M. (2019) Multidisciplinary collaboration and understanding of green infrastructure Results from the cities of Tampere, Vantaa and Jyväskylä (Finland), *Urban Forestry & Urban Greening*, 40, 63-72. <https://doi.org/10.1016/j.ufug.2018.03.012>.

Langemeyer, J. & Connolly, J.J.T. (2020) Weaving notions of justice into urban ecosystem services research and practice, *Environmental Science & Policy*, Volume 109, 1-14. <https://doi.org/10.1016/j.envsci.2020.03.021>.

Liqueste, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., & Zulian, G. (2015). Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. *Environmental Science & Policy*, 54, 268-280. Doi: <https://doi.org/10.1016/j.envsci.2015.07.009>

- Lowy, I. (1992) The strengths of loose concepts – boundary concepts, federative experimental strategies and disciplinary growth: the case of immunology, *History of Science*, 30(4), 371-396. doi: [10.1177/007327539203000402](https://doi.org/10.1177/007327539203000402).
- Martín E.G., Costa M.M., Máñez K.S. (2020a) An operationalized classification of Nature Based Solutions for water-related hazards: From theory to practice. *Ecological Economics*, 167, 106460.
- Martin, E. G., Costa, M. M., Schwerdtner Máñez, K. (2020b) An operationalized classification of Nature Based Solutions for water-related hazards: From theory to practice. *Ecological Economics*, 167, 106460. Doi: <https://doi.org/10.1016/j.ecolecon.2019.106460>
- Mazza, L., Bennett, G., de Nocker, L., Gantioler, S., Losarcos, L., Margerison, C., et al. (2011) Green Infrastructure Implementation and Efficiency. Final report for The European Commission, DG Environment on Contract ENV.B.2/SER/2010/0059, Brussels and London.
- Mell, I., Allin, S., Reimer, M., Wilker, J. (2017) Strategic green infrastructure planning in Germany and the UK: a transnational evaluation of the evolution of urban greening policy and practice. *Int. Plann. Stud.* 1–17.
- Natural England and Landuse Consultants (2009) Green Infrastructure Guidance. Peterborough. <http://publications.naturalengland.org.uk/publication/35033> [accessed 15 05 2019]
- Nesbitt, L., Meitner, M. J., Girling, C., Sheppard, S.R.J. (2019) Urban green equity on the ground: Practice-based models of urban green equity in three multicultural cities. *Urban Forestry & Urban Greening*, 44, 1-13.
- Pakzad, P. & Osmond, P. (2016) Developing a sustainability indicator set for measuring green infrastructure performance. *Procedia - Social and Behavioral Sciences*, 216, 68-79.
- Paulin, M.J., Remme, R.P., de Nijs, T., Rutgers, M., Koopman, K.R., de Knecht, B., van der Hoek, D.C.J. & Breure A.M. (2020) Application of the Natural Capital Model to assess changes in ecosystem services from changes in green infrastructure in Amsterdam, *Ecosystem Services*, 43, 101114. Doi: <https://doi.org/10.1016/j.ecoser.2020.101114>
- Rigo, A., Németh, J. (2018) “We’re not in the business of housing.” Environmental gentrification and the nonprofitization of green infrastructure projects. *Cities*, 81, 71-80.
- Stadt Leipzig (2019b) Ortsteilkatalog 2018 (Municipal Statistics 2018) (in German), Amt für Statistik und Wahlen. Available from: https://static.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.1_Dezi_Allgemeine_Verwaltung/12_Statistik_und_Wahlen/Raumbezug/Ortsteilkatalog/Ortsteilkatalog_2018.pdf accessed 06/2019
- Thomas, K., Littlewood, S., 2010. From green belts to green infrastructure? The evolution of a new concept in the emerging soft governance of spatial strategies. *Plann. Pract. Res.*, 25, 203–222.
- Turkelboom, F., Leone, M., Jacobs, S., Kelemen, E., García-Llorente, M., Baró, F., ... Rusch, V. (2018) When we cannot have it all: Ecosystem services trade-offs in the context of spatial planning. *Ecosystem Services*, 29, 566-578. Doi: <https://doi.org/10.1016/j.ecoser.2017.10.011>
- United Nations (2018) World urbanization prospects: The 2018 revision, highlights. Department of economic and social affairs. *Population Division, United Nations*.
- Van Herzele, A. & Aarts, N. (2013) “My forest, my kingdom”—Self-referentiality as a strategy in the case of small forest owners coping with government regulations. *Policy Science*, 46, 63–81. <https://doi.org/10.1007/s11077-012-9157-7>
- Van Herzele, A., Ceuterick, M., Buizer, M., & Leone, M. (2019) Ecosystem Services as (Co-)performative Practice: Experiences from Integrated Water Management in Flanders. *Ecological Economics*, 162, 29-38. <https://doi.org/10.1016/j.ecoenv.2019.01.084>
- Villegas-Palacio, C., Berrouet, L., López, C., Ruiz, A., Upegui, A. (2016) Lessons from the integrated valuation of ecosystem services in a developing country: Three case studies on ecological, socio-cultural and economic valuation. *Ecosystem Services*, 22, 297–308.
- Wang, J., Banzhaf, E. (2018) Towards a better understanding of Green Infrastructure: A critical review. *Ecological Indicators*, 85, 758-772.
- Zwierzchowska, I., Fagiewicz, K., Poniży, L., Lupa, P., Mizgajski, A. (2019) Introducing nature-based solutions into urban policy – facts and gaps. Case study of Poznań. *Land Use Policy*, 85, 161-175, 2019. <https://doi.org/10.1016/j.landusepol.2019.03.025>.
- Zhu, Z., Rend, J., Liue, X. (2019) Green infrastructure provision for environmental justice: Application of the equity index in Guangzhou, China. *Urban Forestry & Urban Greening*, 46.