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Can we face the challenge: how to implement a theoretical concept of green infrastructure into planning practice? Warsaw case study

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ABSTRACT
While green infrastructure (GI) is now a widely referenced concept, in Poland it is still only discussed among academics and has yet to be implemented. In 2013, the EC recommended that Member States promote the implementation of GI approaches. In recent decades, ecological discourse has dominated Polish cities' planning practice. In Warsaw, this discourse has evolved into the formation of the Warsaw Natural System (WNS) concept. This study examines means of transforming the WNS, which is strictly related to ecological discourse, into a Warsaw Green Infrastructure (WGI). In doing so, we utilise basic principles of GI, namely: integration, multifunctionality, connectivity, and multi-scale and multi-object approaches. The authors expose the main challenges associated with utilising the WNS concept as a point of departure for WGI implementation.

KEYWORDS
Green space planning; green infrastructure; green infrastructure planning principles; Warsaw, Poland

1. Introduction

In recent years, several planning concepts to maintain and enhance green spaces in cities have been applied. Such approaches include the following: ecological networks (Bryant, 2006; Ignatieva, Stewart, & Meurk, 2011; Jongman, Külvik, & Kristiansen, 2004; Opdam, Steingröver, & Rooij, 2006), ecological land use complementation (Colding, 2007; Goddard, Dougill, & Benton, 2010; Jones, Howard, Olwig, Primdahl, & Herlin, 2007), conservation subdivision (Arendt, 2004; Carter, 2009; Freeman & Bell, 2011), low impact development (Dietz, 2007; Pyke et al., 2011) and green infrastructure (GI) (Benedict & McMahon, 2006; Hostetler, Allen, & Meurk, 2011; Mell, Henneberry, Hehl-Lange, & Keskin, 2013 Mell, 2014). Recently, the GI concept has attracted the most interest. Hundreds of scientific publications, guidelines, recommendations and evaluations outlining more or less detailed conceptualisations and definitions of GI have been published worldwide. The scope of these publications has varied depending on the scale and the areas examined. Generally speaking, the following—albeit overlapping—approaches to GI conceptualisation can be identified:

(1) The 'structural' approach (based on ecological network theories), which focuses on the protection of ecosystems and related services (Benedict & McMahon, 2006; Hostetler et al., 2011; Ignatieva et al., 2011);
(2) The 'hydrological' approach, which emphasises sustainable water management practices (Ahern, 2007; Dietz, 2007; Pyke et al., 2011);

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(3) The 'integrated' approach, which particularly highlights the need to integrate various functions, from nature conservation to social benefits for citizens (Madureira, Andresen, & Monteiro, 2011; Mell et al., 2013; Niemelä et al., 2010).

These three approaches to study GI are legible in planning practice instruments, when the GI concept is actualised through GI plans. The structural approach is more often associated with a regional scale, where connectivity between 'hubs' and 'corridors' is stressed, as exemplified in the Maryland's Green Infrastructure Assessment and GreenPrint Program (2004). Among the cities where the 'hydrological' approach was a basis for GI formation are American cities, such as New York, with its NYC Green Infrastructure Plan, A Sustainable Strategy for Clean Waterways (2010, NYC Green Infrastructure Plan, 2014 Annual Report, 2014) and Chicago and Lancaster (City of Chicago Green Stormwater Infrastructure Strategy, 2014; Green Infrastructure Plan, City of Lancaster, 2011). On the other hand, a more 'integrated approach' is presented in Barcelona (Barcelona Green Infrastructure and Biodiversity Plan, 2013), Vitoria-Gasteiz (The Interior Green Belt: Towards an urban green infrastructure in Vitoria-Gasteiz, 2012) and London (Green Infrastructure & Open Environments: The All London Green Grid, 2012).

Despite the popularity of the GI approach, the concept is not widely discussed among professionals in some European countries, including Poland (Giedych, Szulczewska, Dobson, Halounova, & Doygun, 2014). Nevertheless, given the potential role of GI in shaping urban environments through the delivery of ecological services, it must be recognised as an important urban planning instrument and as a strategic approach to sustainable urban development that combines land conservation and land use planning (Benedict & McMahon, 2006; Hostetler et al., 2011; Madureira et al., 2011; Novotny, Ahern, & Brown, 2010).

The European Commission (2013) sets forth the reasons and the need for the implementation of the concept within urban areas as well. It could be considered as a driving force for the development of GI strategy in European cities, as well as in countries where the GI concept has not yet been adopted.

We thus explore and evaluate strengths and limitations of GI implementation in Polish conditions in consideration of existing concepts that have evolved in Poland and that are characteristic for our spatial planning tradition. In this paper, we present and discuss our proposal to implement the GI idea, taking as the point of departure the already existing concept of the Warsaw Natural System (WNS)—a concept aimed at maintaining the correct proportion between built-up and open areas, which is strictly related to ecological discourse and firmly rooted in the Warsaw spatial planning tradition. At the same time, we discuss possibilities and limitations of the implementation of GI principles presented in publications into practice.

2. Materials and methods

2.1. The study area

Warsaw is perceived as a green city. Taking into account the available data (Statistical Office in Warsaw, 2015) on land use structure, land uses, which may constitute the main body of GI, account for 51% of the total Warsaw area (Figure 1). The dominant present land use within those elements is agriculture, and therefore arable lands, pastures, meadows and orchards cover almost 22% of total city area. The second biggest land use category is forests (17% of total city surface), and they are located mainly in urban peripheries. Green spaces represented by 88 parks, 233 smaller pocket parks, allotment gardens, cemeteries, estate and street greenery cover an area of 4 572 ha (8.8% of city area). However, despite a rather large area, the distribution of green spaces in the urban fabric is uneven, as peripheral districts lack public parks. The green space structure is shaped as a combination of a band and wedge system that reflects the natural Warsaw relief with its Vistula river valley, the Warsaw Escarpment and a moraine plateau. Searching for potential for the GI formation in Warsaw, one should consider the outstanding qualities of these elements:

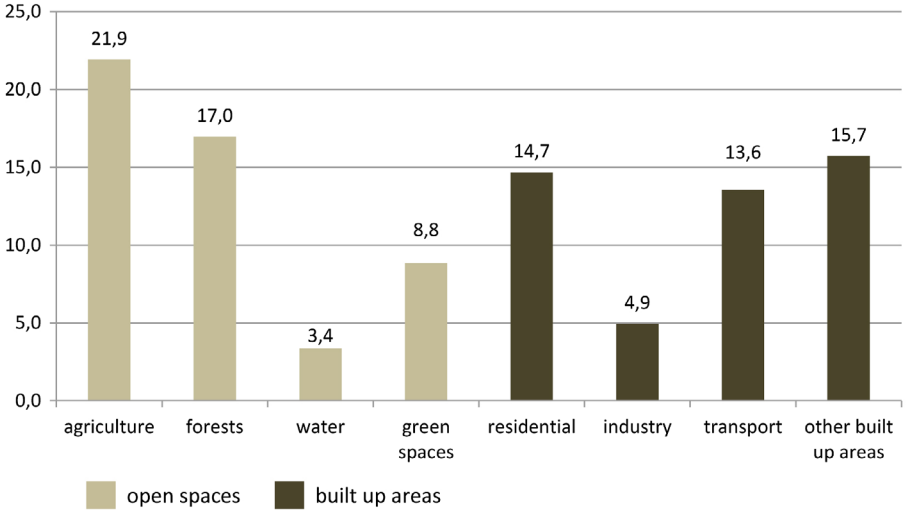

Figure 1. Warsaw land-use structure (in per cents). Source: Statistical Office in Warsaw, 2015.

(1) Natural character of a wide river valley, with features characteristic of a braided river, such as sandbars, floodplains and riparian forests;
(2) A significant landmark of the Warsaw Escarpment whose elevation varies from approximately 20 m in the Old Town area and central district to 10 m in the northern and southern quarters together with forests, magnificent historical parks and gardens, sporting and recreational areas, palaces and other historical buildings that are found along the escarpment;
(3) Still remaining natural landscape, such as patches of forest situated primarily in the outskirts and main alleys of trees that cross the city centre.

2.2. Warsaw Natural System

The concept of the WNS was introduced into Warsaw's Spatial Policy (Warsaw Environmental Study, 2006, amended 2010, 2014), on the basis of the Warsaw Environmental Study (2006) following the theoretical concept published by Szulczewska and Kaftan (1996). It can be defined as a part of the city's area dedicated to stabilising and enhancing environmental processes in the whole city. In order to play this role, areas which belong to the WNS must be developed with particular consideration.

The WNS approach as outlined in the Warsaw Environmental Study (2006) aimed to identify territorial units (areas) relevant for the climatic, hydrological and biological performance of the city. Finally, the WNS was then delineated via subsystems (climatic, hydrological and biological) overlapping analysis. If all three subsystems overlapped, they formed the main body of the WNS, or the so-called core area. Areas that were critical to the performance of two (typically hydrological and biological) subsystems were deemed supporting areas. Areas that heavily influenced the climatic subsystem were also considered as supporting areas.

The final version of the WNS (Figure 2) that was introduced in the Warsaw Spatial Policy includes both major structural elements (core and supporting areas) and linkages between WNS areas (green spaces and street greenery, which form main ecological connections).

The provisions of the Warsaw Spatial Policy in relation to the WNS define its borders, acceptable land use types (Figure 3) and Ratio of Biologically Vital Area (RBVA)—measurements which determine the amount of area covered by vegetation and/or water bodies in relation to sealed surfaces of the spatial unit (Szulczewska et al., 2014).

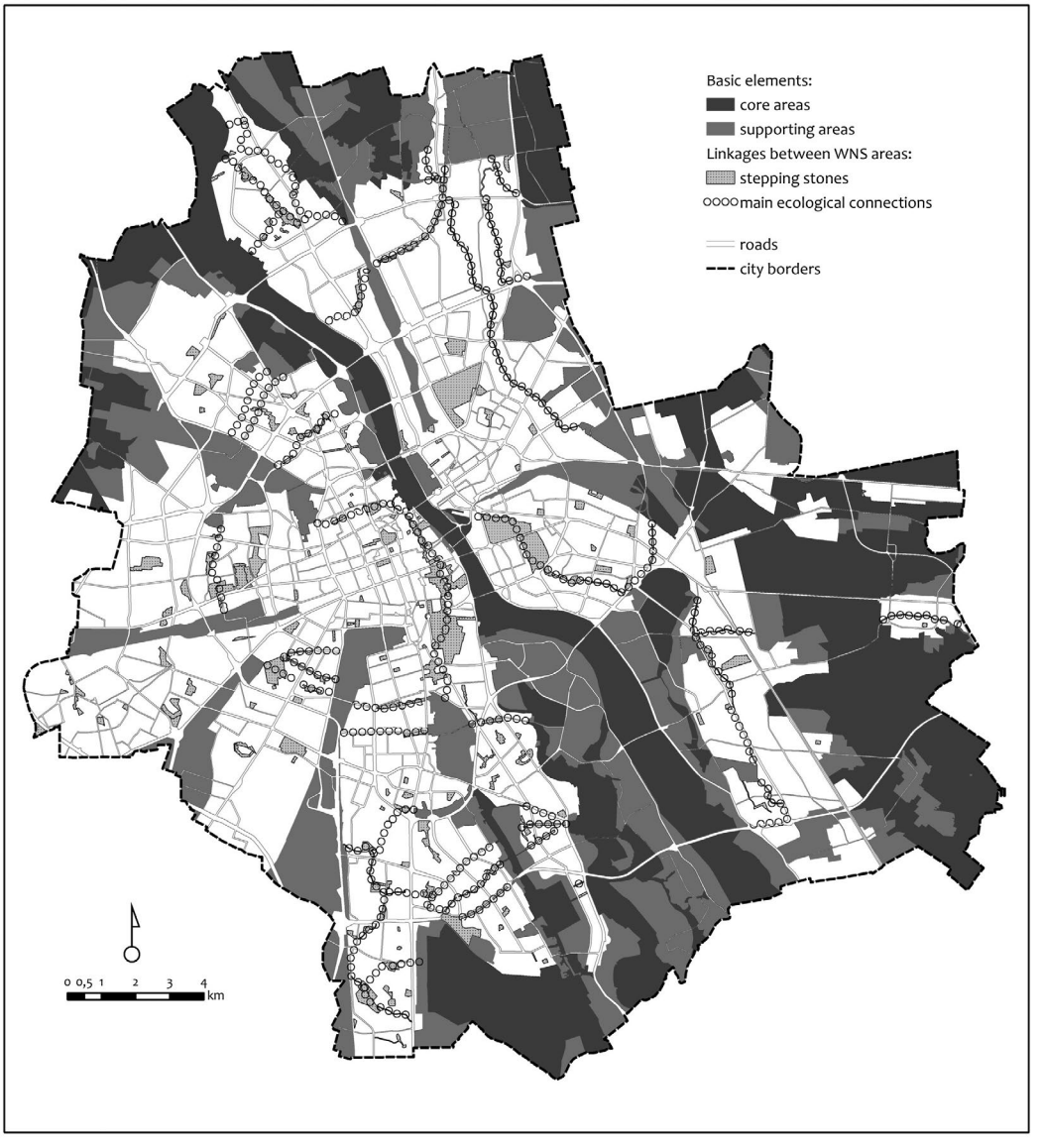

Figure 2. WNS. Source: Elaborated on the basis of Warsaw Spatial Policy, 2006, amended 2010, 2014.

2.3. Adopted methodological approach

2.3.1. Main assumptions

In addressing the possibility of the implementation of the GI concept in Warsaw, we decided to concentrate on the principles that Hansen and Pauleit (2014) identified on the basis of Benedict and McMahon (2006), Kambites and Owen (2006), and Pauleit, Liu, Ahern, and Kazimierczak (2011). Originally, they listed two groups of approaches: addressing the green structure and addressing the governance process. However, as our focus is an examination of the possibilities of embedding GI into the existing Warsaw Spatial Policy, we limited our investigation only to the principles addressing the spatial green structure: (1) integration, (2) multifunctionality, (3) connectivity, (4) a multi-scale approach and (5) a multi-objects approach.

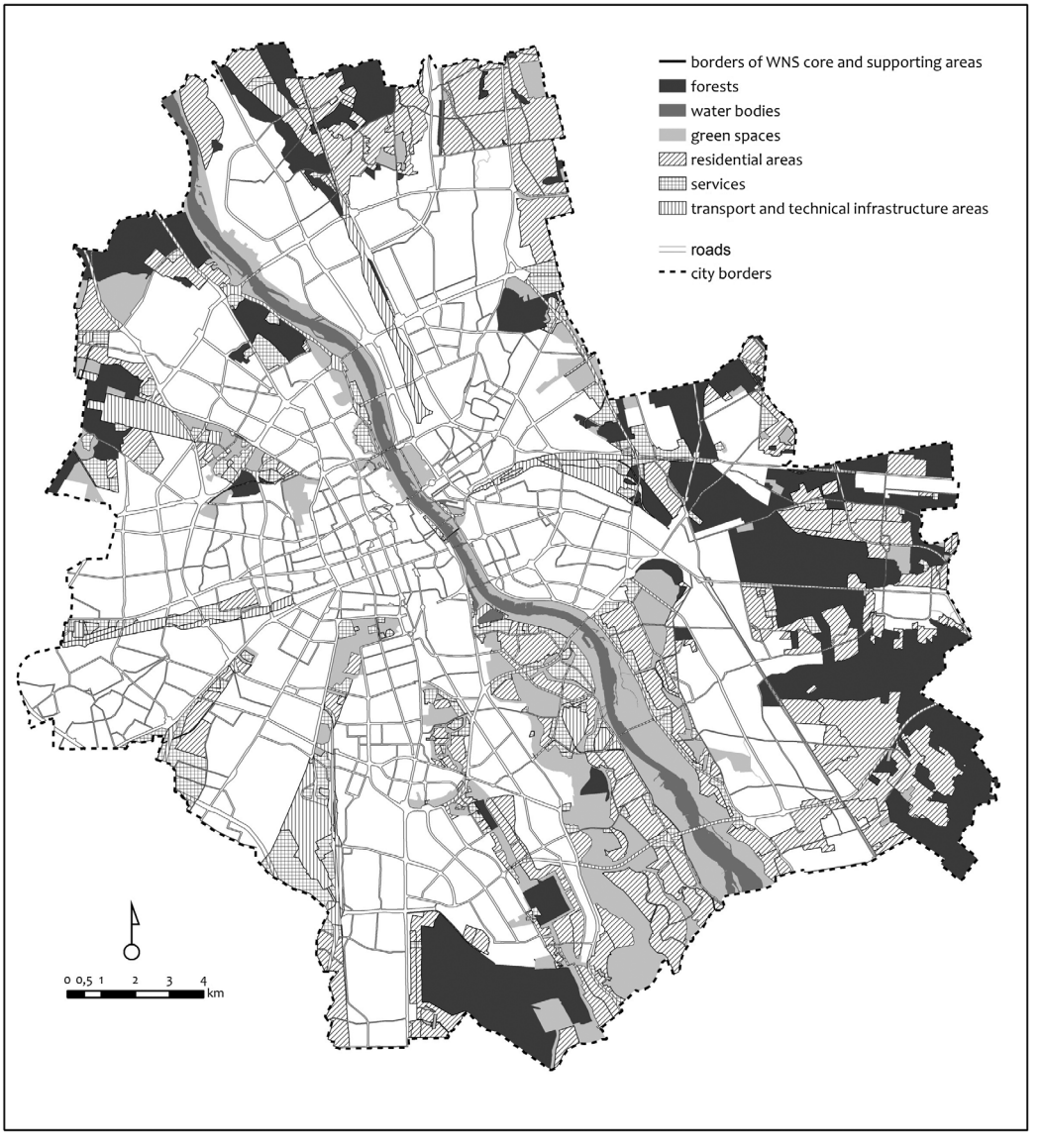

Figure 3. WNS planned land–use structure. Source: Elaborated on the basis of Warsaw Spatial Policy, 2006, amended 2010, 2014.

For the purposes of this study, we define Warsaw Green Infrastructure (WGI) as a system of functionally and/or structurally interconnected objects that are covered by vegetation and water, and which are considered important for a city's environmental performance, climate change adaptation and residents' quality of life.

2.3.2. Materials

Our primary research materials were spatial planning documents: the Warsaw Spatial Policy (Warsaw Spatial Development Conditions and Directions Study 2006 with the amendments of 2010 and 2014) and the local plans (235). The Spatial Policy is a mandatory planning document at the municipal level in Poland, which provides a system of principles to guide decisions on land use and the spatial structure of the city. It also endorses WNS—a concept considered to be relevant for the implementation of WGI

(see point 2.2). According to Polish law on spatial planning (Spatial Planning and Development Act, 2003), legally, this policy is a statement of intent, and it is implemented by the local plans (acts of local spatial law).

In our analysis, we utilised publications which refer to GI implementation strategies (with special consideration given to those describing success stories) in order to establish the scope of the policies that are relevant for GI.

2.3.3. Analyses: scope and procedures

A content analysis of the Warsaw Spatial Policy and the local plans enabled us to discuss the possibility and conditions for the implementation of GI in the updated version of this Policy, which is supposed to be elaborated in subsequent years.

According to the main principles of GI presented by Hansen and Pauleit (2014), we conducted five analyses aimed at recognising WNS characteristics on the background of those principles and their interpretation available in the literature. Based on theoretical considerations and guidelines, in each case we formulated a set of questions derived from particular principle description. Then, we responded to those questions taking into account provisions of the Warsaw Spatial Policy related to WNS and relevant provisions of other policy sectors, which may or should be important for transforming the WNS concept into the WGI model.

In surveying the *integration principle*, we have tried to answer the questions related to the policy sectors relevant for the implementation of WNS and the background of the policy sectors pertinent to GI. Hansen and Pauleit's (2014) integration approach was the first to address the green structure concept, and it has been endorsed in many guidelines and strategies on GI implementation. They indicated the need to integrate GI planning with planning other urban infrastructure (e.g. transport, water management) and structures (e.g. built-up areas). In order to follow this guideline, policy sectors that are considered relevant to GI implementation must be identified and utilised.

Table 1. Policy sectors determined as necessary for GI implementation.

Policy sector to be included in GI planning and management	Analysed guides and strategies							
	1	2	3	4	5	6	7	8
Development policy		x		x	x	x	x	
Spatial policy		x		x				
Housing policy		x			x			
Transportation		x				x		
Food production		x					x	
Energy production/efficiency		x						
Rainwater, flooding and wastewater management	x	x	x		x	x	x	x
Climate change mitigation/adaptation				x	x		x	x
Nature protection (biodiversity)					x			x
Cultural heritage protection						x		x
Landscape protection		x						x
Fibre and fuel production				x				x
Health		x			x			x
Education							x	x
Recreation				x	x	x	x	
Public space							x	

(1) Rutherford (2007) The GI Guide. Issues, Implementation Strategies and Success Stories
(2) Natural England (2008) The Essential Role of GI: Eco-towns GI Worksheet
(3) American Rivers, Association of State and Interstate Water Pollution Control Administrators, National Association of Clean Water Agencies, Natural Resources Defence Council, The Low Impact Development Centre, U.S. Environmental Protection Agency (2008) Managing Wet Weather with GI Action Strategy
(4) Land Use Consultants (2009) South East GI Framework. From Policy into Practice
(5) Natural Economy Northwest (2009) A Guide to Planning GI at the Sub-Regional Level DRAFT (v3.1)
(6) Green Infrastructure Centre and E^2 Inc. (2010) Richmond Green Infrastructure Assessment
(7) Landscape Institute (2011) Local GI. Helping communities make the most of their landscape
(8) The Royal Institution of Chartered Surveyors (2011) GI in Urban Areas. RICS Practice Standards

Analysis of eight different GI implementation guides and strategies (Table 1) revealed that depending on the document, varied sets of policies have been recommended. It is obvious that discrepancies in the examined approaches have resulted from differing conceptualisations of the 'GI' term. Additionally, the analysis revealed that water and wastewater management should guide the GI implementation policy sector. This view, however, results from a very strong conceptualisation of GI as a measure for promoting sustainable water (particularly storm water) management (Ahern, 2007; Dietz, 2007; Pyke et al., 2011). All of these findings demonstrate that during GI implementation, relevant policy sectors must be identified independently, according to specific problems of each city.

In examining the *multifunctionality principle*, we have tried to compare the scope of the functions assigned for WNS with the GI functions and to explore the possibility of the implementation of this principle, while formulating the Warsaw Spatial Policy's provisions. Hansen and Pauleit (2014) explain that *multifunctionality principle* aims at intertwining or combining different functions, and thus using limited space more effectively. Taking into account numerous, and sometimes conflicting functions of GI (Green Infrastructure and Territorial Cohesion, 2011) it seems that this principle can be fully implemented at the site level for particular GI elements. Concepts and frameworks for GI multifunctionality assessment and planning presented by Hansen and Pauleit (2014) revealed that the whole procedure seemed to be rather demanding. Utilisation of the ecosystem services concept in this procedure requires a proper set of indicators, whose elaboration demands data rarely available for all potentially considered services.

In considering the *connectivity principle*, we were interested in the extent to which WNS was planned as a coherent structure and whether WGI could follow this structure. Hansen and Pauleit (2014) defined connectivity as physical and functional connections between green spaces. This connectivity, according to e.g. Ahern (2007) and Chang, Li, Huang and Wu (2012), is usually referred to as mainly ecological. Hansen and Pauleit (2014) point out that in the case of GI, the term connectivity should be understood in a wider context and linked to its multiple functions. They also refer to Davies, MacFarlane, McGloin, and Roe (2006) and their matrix (linking quality of GI elements with the connectivity). Connectivity analyses also require addressing two crucial issues: (1) Establishment and maintenance of corridors (Fleury & Brown, 1997; Osborn & Parker, 2003; Palmores, 2001; Viles & Rosier, 2001) or greenways (Ahern, 1995, p. 2) Presence of barriers (physical obstructions) or gaps (interruptions to continuity) (Parker, Head, Chisholm, & Feneley, 2008).

In analysing the *multi-scale principle*, we were interested in the extent to which the implementation of WNS has followed this principle and whether the rules applied for WNS could be utilised for WGI. Hansen and Pauleit (2014) mentioned that GI planning was to be performed at different scales: from the individual parcel to the state. This multi-scale approach is typically applied in Europe for the purposes of GI planning and GI spatial analysis (European Environment Agency, 2014). This approach is also supported in extensive studies on ecological networks (e.g. Bryant, 2006; Ignatieva et al., 2011; Jongman et al., 2004; Opdam et al., 2006).

In the case of the *multi-object principle*, we have identified the types of land uses planned for WNS that can be recognised as WGI elements. Hansen and Pauleit (2014) emphasised that different kinds of urban green and blue can be considered as GI objects. According to Benedict and McMahon (2006), GI consists of a wide range of open spaces that maintain ecological processes, e.g. waterways, wetlands, forests, wildlife habitats and greenways. In urban areas, GI may also refer to green roofs and vegetated bioswales (Ahern, 2007), domestic gardens (Goddard et al., 2010) and street trees (Ignatieva et al., 2011). Davies et al. (2006) present a wide selection of GI elements in a detailed typology. Represented overall categories are: agriculture (including 11 GI elements, e.g. horticulture, stock grazing), green spaces (including nine different GI elements, e.g. public parks and gardens, public provision for children and young people), transportation (with greenways, quiet lanes, cycle routes or canals), burial grounds (e.g. cemeteries, disused churchyards), restricted access green spaces (e.g. retail park settings) or controlled access green spaces (e.g. airports and military training land), vacant land (e.g. land identified for development or derelict land), waterways and water reservoirs (e.g. rivers, ponds, wetlands) and other open spaces such as beaches or dunes. From this wide selection of GI objects, one can suppose that any object or area covered by vegetation and/or water should be considered as a GI element. The problem appears that

different types of GI objects should be considered at different levels of GI implementation and from this point of view the multi-scale approach seems to be crucial.

3. Results: questions and answers for Warsaw

3.1. Integration principle

- Which policy was considered as the most appropriate to implement the WNS? Is it correct from the WGI implementation point of view?

Table 2. Integration of WNS implementation provisions with the provisions of other policies.

Spatial policy sectors relevant to GI development (based on Table 1)	Policy sector provisions that may affect WNS development	Provisions directly targeted at WNS development
Development policy	This policy does not contain provisions related to GI	
Spatial policy	Minimum ratio of biologically vital areas (25–40% for residential areas)	Minimum ratio of biologically vital areas (40–60% for residential areas located within the WNS) Minimum ratio of biologically vital areas (70–90% for green spaces)
Housing policy	This policy does not contain provisions related to GI	
Transport	Bicycle route system developed as a supporting transportation system	No specific provisions
Food production	All existing agricultural areas are to be transformed into residential or green spaces (parks or sports centres)	No specific provisions, though a significant number of existing agricultural areas are located within the WNS framework
Energy production/efficiency	This policy does not contain provisions related to GI	
Rainwater, flooding and wastewater management	Recommended sustainable drainage system and rainwater management along the borders of individual plots Prohibition/ban on building within 10 m of watercourses and water bodies	No specific provisions
Climate change mitigation/ adaptation	Not applicable; this policy was not included in Warsaw Spatial Policy	
Nature protection (biodiversity)	Reference to existing and planned nature protection areas and guidelines on their protection	The WNS is deemed a structure that is responsible for the environmental performance of the city of Warsaw (other functions e.g. residential, recreational are to be subordinate to the main function) Special guidelines on protection areas are included in the WNS (among others: green connections—a minimal width of 10 m)
Cultural heritage protection	Reference to existing historical heritage conservation zones and to guidelines on their protection/development Designation of areas that are to be protected as cultural parks	No specific provisions, though some protected objects or objects to be protected are located within the WNS framework
Landscape protection	Reference to natural relief and anthropogenic forms that are deemed important landmarks	No specific provisions, though some landmarks are located within the WNS framework
Fibre and fuel production	Not applicable; this policy was not included in Warsaw Spatial Policy	
Health	This policy does not contain provisions related to GI	
Education	This policy does not contain provisions related to GI	
Recreation	Standards: parks—10 m^2 per inhabitant sports areas—40 m^2 per inhabitant, walking distance to green spaces—10–20 min	No specific provisions
Public space	The enhancement, development and redevelopment of public spaces with particular attention to social and aesthetic attributes	No specific provisions

Provisions of the Warsaw Spatial Policy, directly related to the WNS, were placed in the section dedicated to environmental protection policy. That is in tune with the main assumption on which the WNS concept was based: to safeguard and protect space responsible for the environmental performance of the city. In the case of the WGI, however, such placement seems to be inappropriate. Taking into account the general GI idea, its role and functions, as well as the wide selection of policies important for GI development and implementation, three options of WGI presentation in planning documents may be considered: (1) WGI as an 'independent' policy sector on the same level as e.g. transportation or housing policy; (2) WGI as part of the chapter on spatial structure of the city; (3) WGI as an element of different policies already included into the Warsaw Spatial Policy, but upgraded in terms of WGI implementation.

- To what extent provisions of policy sectors, already included into the Warsaw Spatial Policy, may be important for WGI implementation?

First, it should be noted that most of the policies (Table 2) already encompassed—as policy sectors—in the Warsaw Spatial Policy were considered to be relevant for the implementation of GI. Of course, the scope of those policy sector provisions should be expanded, as they were designed only for WNS, and not in order to introduce a more multifunctional WGI.

Table 2 also shows that not all of the policy sectors considered to be relevant for the implementation of GI (such as development policy, health, housing, education, fibre and fuel production) are incorporated in the Warsaw Spatial Policy. This means that the WGI concept should be included, while other strategic documents are to be prepared (usually in the case of Polish municipalities: a development strategy, an environmental protection programme and a climate change adaptation/mitigation policy, which have just started to be elaborated in Polish cities).

3.2. Multifunctionality principle

- What sort of functions are intended to be developed within the WNS, according to the Warsaw Spatial Policy?

According to the WNS concept (see Section 2.2), environmental functions (climatic, hydrological, biological) must be considered as the principal ones. As stated in the Warsaw Spatial Policy, subordinated to them are other functions, such as: residential, recreational, leisure and aesthetical. It should be noted that those functions were mentioned as 'among others', which means that it is an open list. The reason for such an approach lies in the WNS concept, where not function but location and environmental characteristics of the area are crucial for its incorporation into the system.

- To what extent are functions planned within the WNS consistent with GI functions?

In order to refer to the multifunctionality issue, we could only compare the main assumptions for WNS and WGI creation and identify planned functions of the areas included in the WNS, taking into account planned land uses. That allowed us to identify functions, however it did not permit a full evaluation of their scope and meaning for the particular land use as well as for the whole GI network. The point of departure for function identification was their enumeration included in the publication: Green Infrastructure and Territorial Cohesion (2011). Results of the analysis are presented in Table 3.

Analysis of Table 3 revealed that not all GI functions were planned to be developed within the WNS. It is obvious that due to the general WNS idea and its character, first of all environmental functions were planned. Further study of the provisions of the Warsaw Spatial Policy sectors (e.g. spatial structure, cultural heritage protection, water management), referring to issues other than WNS, allowed us to identify that some social functions were also assigned to selected areas within the types of land use included in the WNS. There are, however, GI functions that are not mentioned in the Warsaw Spatial Policy: e.g. maintaining the potential for agricultural land and providing space for renewable energy. This occurred because the Warsaw Spatial Policy's provisions did not foresee the types of land uses which could host those functions.

Table 3. WGI functions that are planned to be developed within the WNS.

Types of land use included in the WNS that could host particular functions / GI functions according to Green Infrastructure and Territorial Cohesion (2011)	Parks	Green spaces adjacent to sport and leisure facilities	Historic parks in forests	Forests	Vistula river green spaces	Cemeteries	Built-up areas (min. 60% of rbva)	Single-family housing	Single-family housing in forests	Health care services	Sport and recreation areas	Educational services
Habitats for species	+	+	+	+	+	+	+	+	+	+	+	+
Permeability for migrating species	+	+	+	+	+	+	+	+	+	+	+	+
Connecting habitats	+	+	+	+	+	+	+	+	+	+	+	+
Mitigating urban heat island effect; corridors for air ventilation	o	o	o	o	o	o	o	o	o	o	o	o
Storing flood water; ameliorating surface water run-off	o	o	o	o	o	o	o	o	o	o	o	o
Carbon sequestration	–	–	–	-	–	–	–	–	–	–	–	–
Encouraging sustainable travel	–	–	–	-	–	–	–	–	–	–	–	–
Reducing energy use (heating and cooling)	–	–	–	-	–	–	–	–	–	–	–	–
Providing space for renewable energy	–	–	–	-	–	–	–	–	–	–	–	–
Sustainable drainage systems attenuating surface water run-off	o	o	o	o	o	o	o	o	o	o	o	o
Groundwater infiltration	+	+	+	+	+	+	+	+	+	+	+	+
Removal of pollutants from water	–	–	–	-	–	–	–	–	–	–	–	–
Direct food and fibre production	-	-	-	-	-	-	-	-	-	-	-	-
Keeping potential for agricultural land	–	–	–	-	–	–	–	–	–	–	–	–
Soil development and nutrient cycle	–	–	–	-	–	–	–	–	–	–	–	–
Preventing soil erosion	o	o	o	o	o	o	o	o	o	o	o	o
Cleaner air	–	–	–	-	–	–	–	–	–	–	–	–
Positive impact on land and property	–	–	–	-	–	–	–	–	–	–	–	–
Local distinctiveness	o	o	o	o	o	o	–	–	–	–	–	–
Sense of space and nature	o	o	o	o	o	o	–	–	–	–	–	–
Recreation	+	+	+	+	+	+	–	–	–	–	–	–
Opportunities for education, training and social interactions	+	+	+	+	+	+	–	+	–	–	+	+
Tourism opportunities	o	o	o	o	o	o	–	–	–	–	–	–

- functions that are to be developed, according to the provisions of the Warsaw Spatial Policy chapter referring to the WNS
- functions that are to be developed in selected areas of the WNS, according to the provisions of the Warsaw Spatial Policy chapters, referring to other than WNS issues (e.g. spatial structure, cultural heritage protection, water management)
- functions that are not mentioned, according to the provisions of the Warsaw Spatial Policy

An analysis of the Warsaw Spatial Policy also exposed some issues that should be raised from a methodological point of view. We argued that a land use approach, in which functions have been identified on the basis of the type of land use, seems to be insufficient for WGI (e.g. cultural functions, such as creating a landscape identity, could not be identified on the basis of a land use analysis). In order to analyse and plan functions of WGI elements, particular objects should be documented. Only for them it would be reasonable to analyse individually current functions, assess their significance, potential conflicts and finally plan for the future. Also an inventory of WGI functions should be redefined on the basis of its object documentation. For example, there might be different types of recreation, tourism or education possibilities depending on the object.

3.3. Connectivity principle

- Is the WNS planned as a coherent structure? What are the prospects of implementing the WNS as a coherent structure?

The WNS, according to its assumptions, was planned as a coherent structure. Its linkages with the regional ecological network (assured by the Vistula valley and the vast forest complexes) were also taken into account as an indispensable condition for the performance of the WNS (Figure 5). The integrity of the WNS was determined through the delineation of the core and supporting areas and the recommendations for the development of greenways (street plantations) (Figure 2). In several cases (especially in densely built-up areas), however, connectivity between individual areas of the WNS have still not been accomplished (the recommended linkages have not yet been completed). It should be stressed that over the course of the delineation of the WNS, a focus was placed on functional connectivity. The empirical evidence on whether and how the planned linkages function is still insufficient.

An analysis of planned spatial structure of the city as well as its transportation system allowed us to identify the presence of barriers (physical obstructions) and gaps (interruptions in continuity). So, in answering the question related to the prospects of implementation of the WNS as the coherent structure, we should raise the following concerns:

(1) The planned land use structure within the boundaries of the WNS is varied. In the WNS core areas, forests and parks prevail, although residential areas also exist. WNS supporting areas include nearly all urban functions. This implies that in some WNS supporting areas, land use other than the green and/or blue spaces are widespread (Figure 3); in such cases, connectivity may be achieved only through the development of different land cover features. Safeguarding and implementation of vegetation as the most welcome land cover in the case of structural and functional connectivity of the WNS may be addressed through planning measures by manipulating the size of the RBVA. As application of the RBVA is a quantitative rather than qualitative measure, physical connectivity should be developed by site-scale solutions. This issue is discussed in the *Multi-scale approach* section.
(2) Existing and planned main roads create physical barriers that affect WNS connectivity (Figure 4). The best WNS continuity conditions were found along the Vistula river corridor.
(3) The existence of the Vistula valley, forests and other open spaces in the vicinity of the city is enabling the development of connectivity at metropolitan and regional level (Figure 5).

- To what extent does the WGI follow the structure of the WNS? What sort of corridors and/or greenways could be/should be developed in order to enhance WGI connectivity?

To a certain extent the WGI follows the WNS structure. That is obvious because certain areas /land uses which form the WNS must also be considered as WGI objects. At this moment of analysis, it is too early to decide precisely which areas/objects will form the WGI structure at the city level, but main links, particularly within the core areas can be utilised for WGI. This ecological /environmental connectivity will solve half of the connectivity problem. The other half, according to GI connectivity rules, refers to movement of people between GI objects. In GI ideology, there is a strong belief that

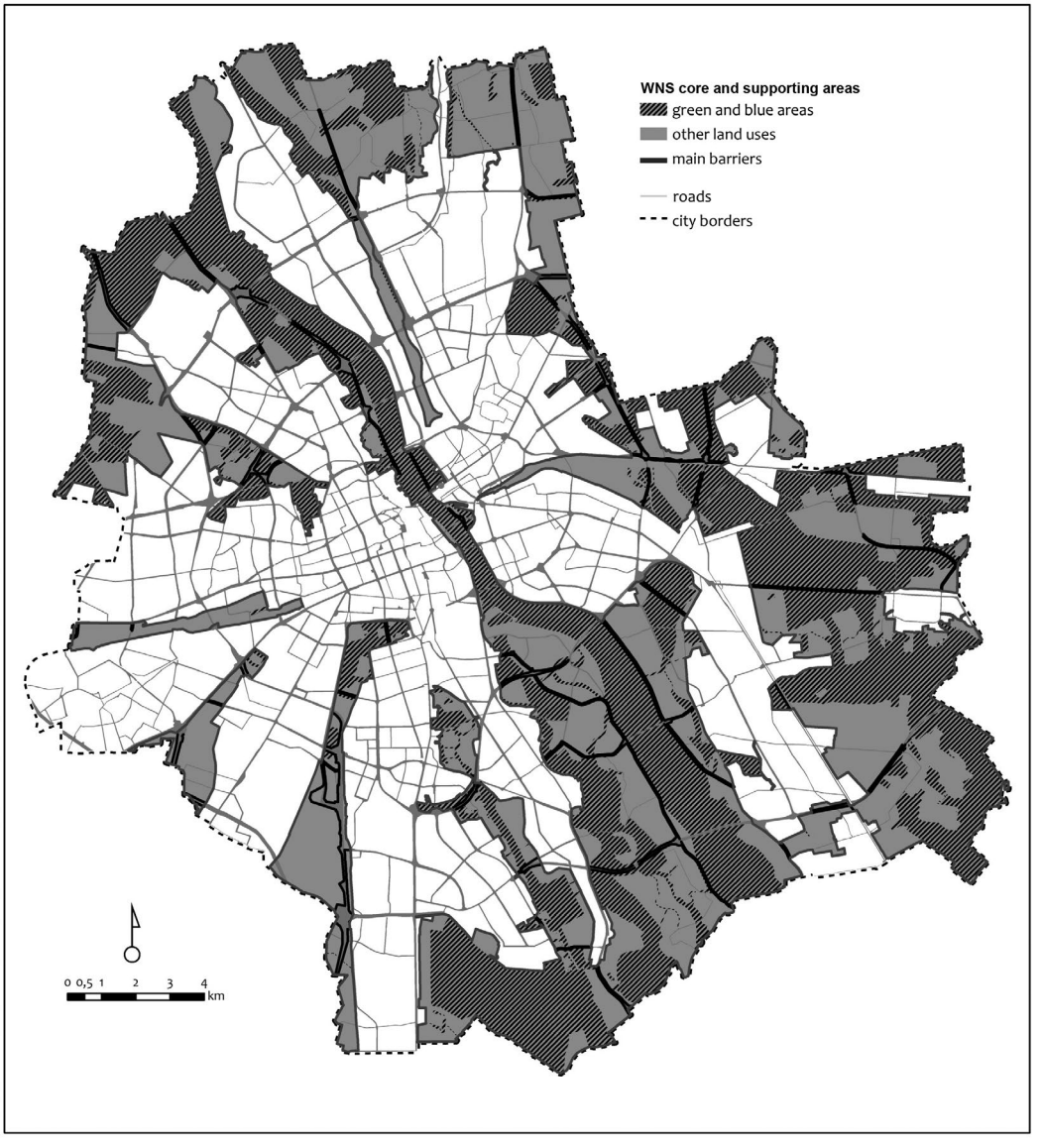

Figure 4. WNS connectivity problems. Source: Author.

this movement should be performed by foot or bicycle (sustainable transportation). Such systems are still under construction in Warsaw and at the moment, the priority is given to support transport not to connect existing parks and other green spaces.

3.4. Multi-scale approach principle

- Is the WNS concept based on the multi-scale principle?

The multi-scale approach to the implementation of the WNS formed one of the main assumptions on which this concept was based. According to the Warsaw Spatial Policy, the WNS is considered to be an element of the wider regional ecological network. WNS delineated at the city level was supposed to be implemented through spatial development of particular areas (land uses), according to certain rules presented in the Warsaw Spatial Policy. So, local plans since the beginning have been considered as the main measure of WNS implementation. Thus, to verify the adopted assumption, we analysed

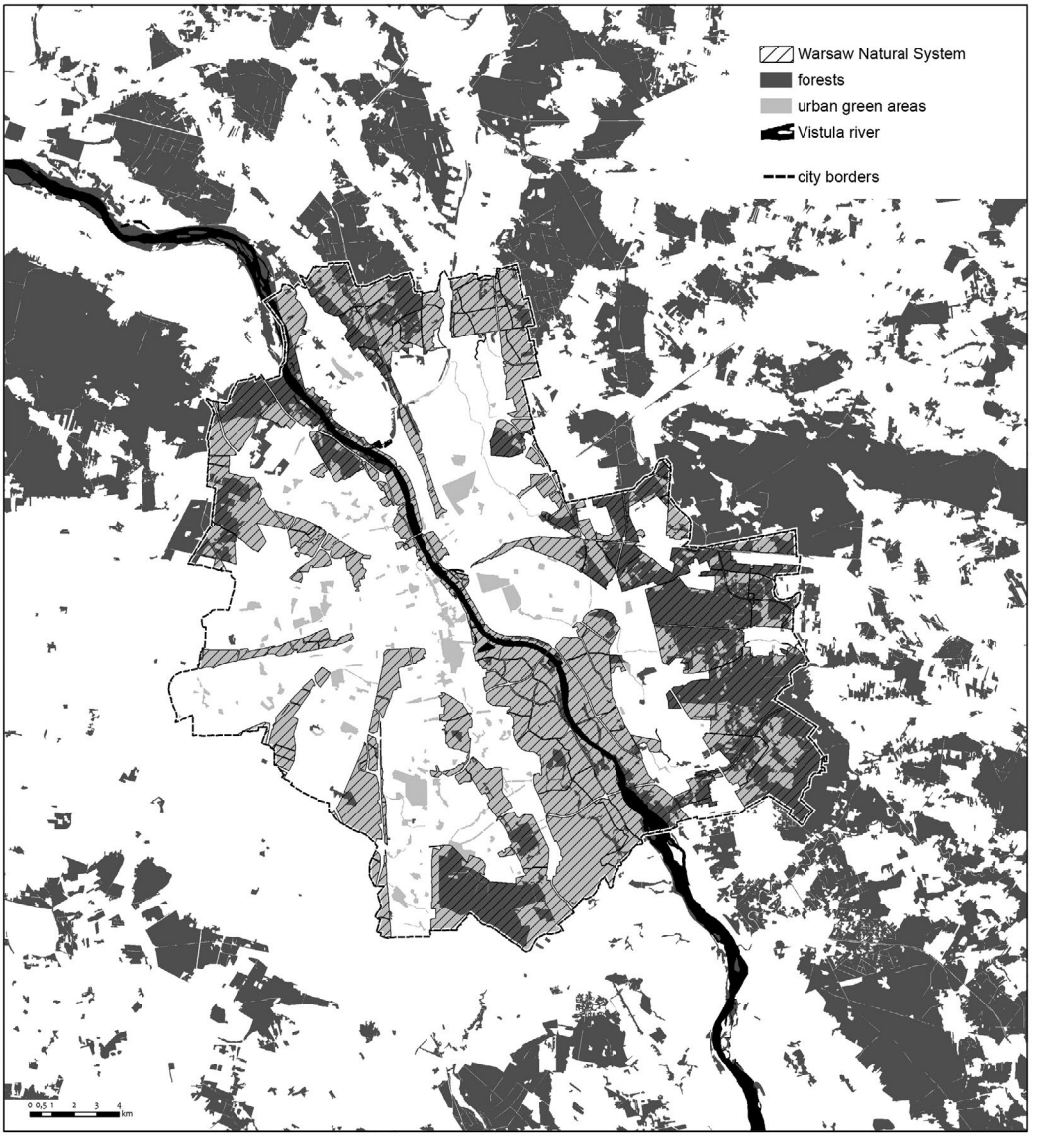

Figure 5. Connectivity of WNS with ecological network at the metropolitan level. Source: Author.

the distribution and spatial scope of local plans in force that are related to WNS issues. Information on local plans was acquired from the City of Warsaw's on-line map service.

The analysis revealed that local plans have been prepared only for certain areas of the WNS (Figure 6). Thus, only for these areas are recommended RBVA sizes maintained. Of course, complying with this recommendation does not guarantee a favourable result. This instead depends on green space layout and vegetation characteristics. Areas of the WNS for which no local plan has been developed may thus not be addressed. That creates one of the main problems of the WNS implementation.

- To what extent could/should WGI follow the WNS implementation rules?

Local plans, which are in fact the only instrument for WNS implementation, do not seem to be sufficient for WGI. Also taking into account multi-object principles (see Section 2.3.3) and depending on the

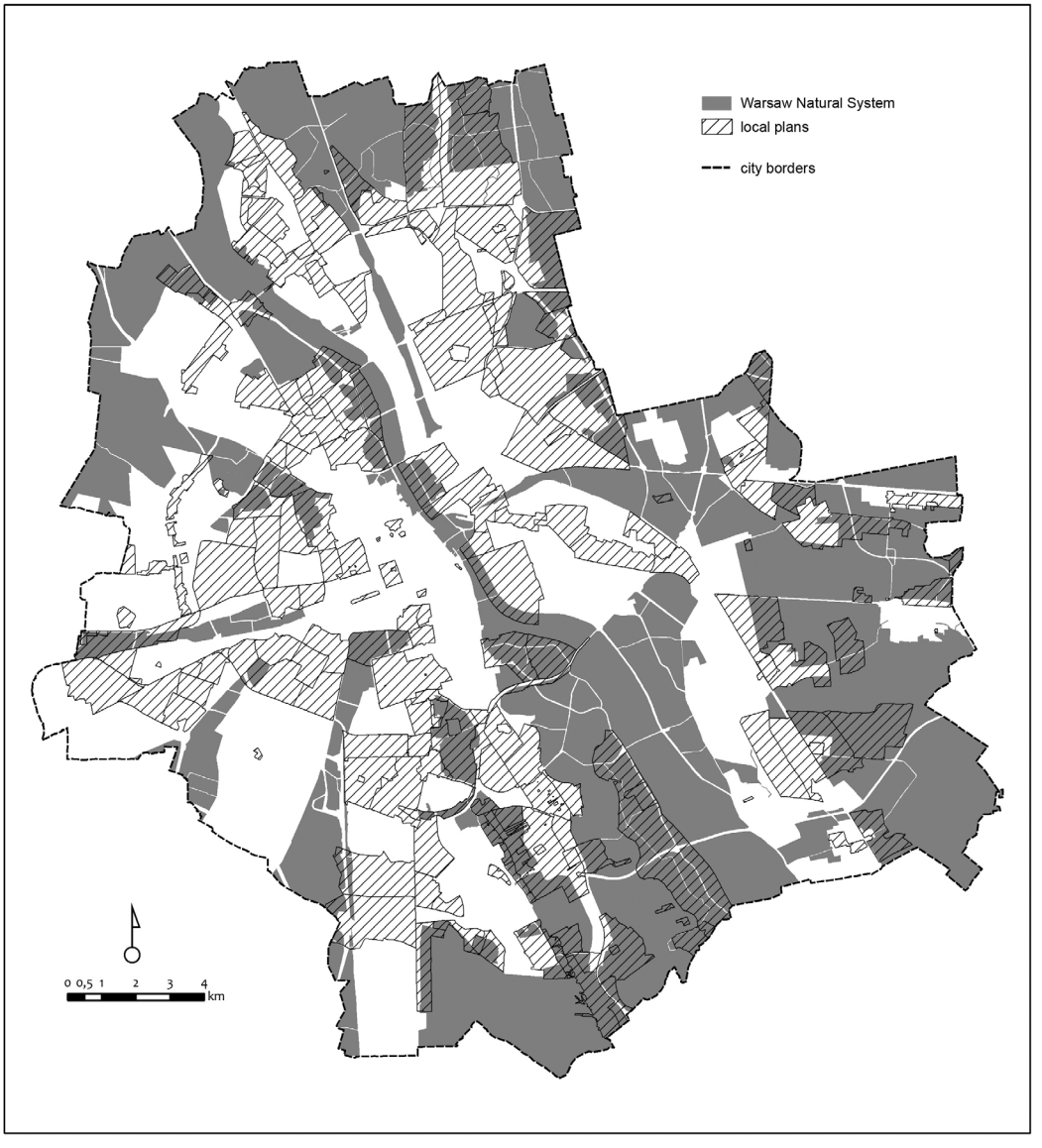

Figure 6. Local plans as a measure for WNS implementation. Source: Author.

respective scale, different sets of instruments for the implementation of WGI should and could be designed. Instruments for the implementation of WGI at the site scale could be considered bottom-up initiatives which have just appeared in Warsaw's different districts and neighbourhoods (e.g. the enhancement of green spaces in the framework of participatory budgets). On the other hand, at the city level a new programme called 'One million trees', similar to that carried out in New York, Chicago and other cities has been launched. All such initiatives need co-ordination and the WGI umbrella seems to be the right one.

3.5. Multi-object principle

The multi-object approach did not underpin the WNS concept. However, taking into account the types of land uses which can be developed within the WNS borders (see Figure 3) we identified those types which are in tune with the GI typology formulated by Davies et al. (2006).

The analysis revealed that while the WNS is diverse, not all planned land uses serve as potential GI elements at the city scale. Nevertheless, it should be stressed that GI is a hierarchal concept (see Section 4.4), and thus even in zones designated for land uses that are not part of city-scale GI, actual GI elements can be delivered at the site scale (e.g. green roofs, green walls).

A comparison between potential elements of WGI (based on the typology developed by Davies et al., 2006) with planned WNS land use categories reveals a number of gaps or divergences. GI land uses that are not planned for in the WNS include: agriculture areas (including all arable land for horticulture, orchards, allotments, community gardens and urban farms).

4. Conclusions: prospects for WGI

In this paper, we have discussed a possibility of GI idea implementation, taking as a point of departure the WNS concept, already existing in Warsaw's spatial planning tradition. Before presentation of prospects for WGI implementation, two important remarks should be made.

(1) Since the last decade of the twentieth century, the idea of the WNS and its precursors has been present in Warsaw's planning documents. Planners, public officers, decision makers accepted it and got used to it. That is why we suggest to preserve the WNS as a 'natural layer' on which WGI will be developed
(2) In our paper, in discussing possible WGI development, we have followed the principles presented by Hansen and Pauleit (2014), but in an order that is a bit different. This turned out to be more reasonable from the point of view of transforming the WNS into WGI.

4.1. Objects

WNS consists of different areas representing various land uses while WGI should be presented as a system of defined objects—protected, managed, redeveloped, all according to GI principles. The city must decide which of the objects are of strategic importance. Those should be a stable element of city spatial structure and will form WGI at the city level. It should also be decided what type of objects should be promoted at district and neighbourhood levels. It is obvious that for Warsaw, Vistula Valley and the Warsaw Escarpment will form the main elements of the WGI. But in order to manage those areas efficiently, precise borders of those elements should be established and agreed. There is also a decision to be made, regarding which parks, from the existing 88 ones, are of strategic importance. WGI plans are challenged by visions of spatial development that do not provide space for agriculture or allotment gardens. This issue needs to be discussed with Warsaw authorities, especially given the growing popularity of urban agriculture.

Residential areas and ways in which accompanying green spaces are designed, managed and maintained appear essential to WGI. Those areas directly influence the quality of life and can form connecting links between strategic WGI objects.

4.2. Multi-scale

WGI plans and strategies must adopt a multi-scale approach. There are two scenarios for possible concept implementation:

(a) The implementation of WGI is to be led by the municipal authorities based on a common conceptualisation of the citywide WGI. Amongst the relevant administrative bodies are the Environmental

Protection Department (formally responsible for the implementation of the WNS and green space policy) and the Architecture and Spatial Planning Department (formally responsible for the Warsaw Spatial Policy). In our opinion, the most important issue lies in the detailed analyses of the potential GI implementation measures, which are based on the spatial, social, economic and organisational conditions in Warsaw;

(b) The implementation of WGI is to be realised on the basis of local initiatives supported by various funding streams (e.g. community gardens, playgrounds and pocket parks). In such a case, the municipal authorities serve as an umbrella organisation that supports, advises and coordinates the local initiatives.

Of course, the predicted scenarios must not be viewed as competing with one another, but rather as complementary. Such approaches may thus be implemented simultaneously. However, this will depend on the political will of officials and on management practices in force in the City of Warsaw.

4.3. Connectivity

The implementation of this principle in the case of the WNS should be considered partially successful. The transportation network in Warsaw creates unavoidable barriers and gaps in a coherent WNS network. On the other hand, roads with accompanying street greenery, such as alleys, can be seen as linkages. Warsaw, however, is fortunate because a partly wild river valley crosses the city. Furthermore, the Warsaw Escarpment facilitates connectivity between the WNS elements. Special attention should be paid to different forms of planned connection (greenways and watercourses). While these connections are central to the WNS (and future WGI) functioning, the Warsaw Spatial Policy is too vague for these features to be established. Local plans (site level) seem to be crucial for fulfilling the connectivity principle.

4.4. Multifunctionality

For the WNS, it was limited to specific environmental functions. However, some social functions were assigned for selected areas included in the WNS. Key problems for WGI implementation lies in the evaluation of possible WGI objects from the point of view of their present and required functions: environmental and social, but in a more refined way.

4.5. Integration

This principle has been understood as an integration of different policy sectors relevant for GI implementation. This kind of integration has not been fully achieved in the case of the WNS due to its 'environmental' character and scope of the Warsaw Spatial Policy. Nevertheless, conducted analysis allowed us to consider not only the importance of policy sector integration (usually policy provisions refer to general rules and standards) but integration of these rules and standards on the particular GI area/object. It seems that integration should be performed not only at the level of policy sector but also at the level of particular objects, in their management rules and/or plans.

4.6. To sum up

On the basis of our analysis we can tell that Warsaw is able to face the challenge of GI implementation and the WNS may serve as a good point of departure for identification and characterisation of WGI objects. We also ponder the meaning and usefulness of 'old' concepts that have evolved from the planning tradition of different cities, as they are still significant and should not be put away. At the same time, we addressed and tested theoretical assumptions and principles of GI implementation. We proved their relevance but also found the need for their specifying and tuning.

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