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METHODS, TOOLS AND BEST PRACTICES TO INCREASE THE CAPACITY OF URBAN SYSTEMS TO ADAPT TO NATURAL AND MAN-MADE CHANGES

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CALL FOR PAPERS: TEMA VOL. 11 (2018)

The Resilience City/The Fragile City.
Methods, tools and best practices.

The fragile/resilience city represents a topic that collects itself all the issues related to the urban risks and referred to the different impacts that an urban system has to face with. Studies useful to improve the urban conditions of resilience (physical, environmental, economical, social) are particularly welcome. Main topics to consider could be issues of water, soil, energy, etc.. The identification of urban fragilities could represent a new first step in order to develop and to propose methodological and operative innovations for the planning and the management of the urban and territorial transformations.

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- the territorial risks and fragilities related to mobility of people, goods, knowledge, etc.;
- the housing issue and the need of urban regeneration of the built heritage;
- socio-economical behaviour and the "dilemma" about emergency and prevention economy;
- the city as magnet of the next future's flows (tourism, culture, economy, migration, etc.).

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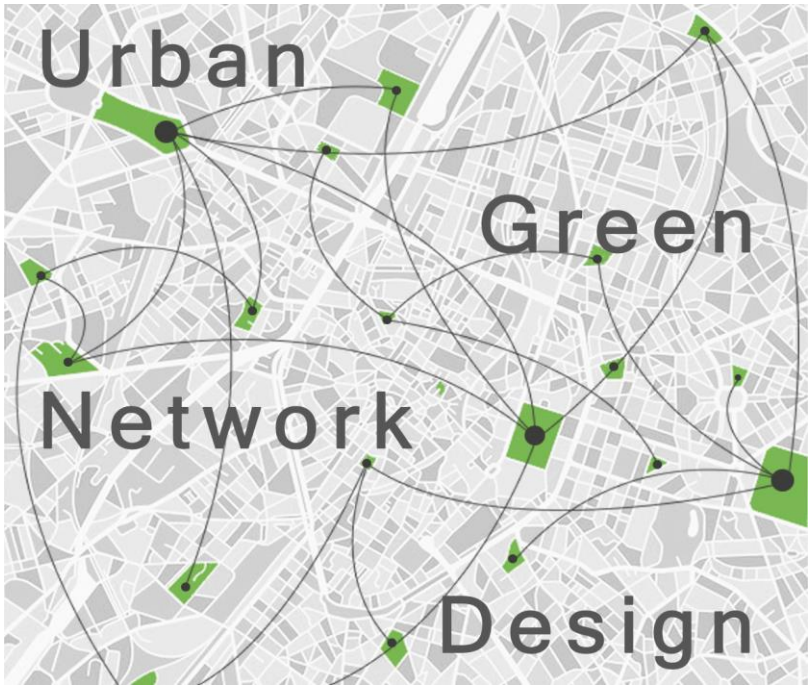

URBAN GREEN NETWORK DESIGN

DEFINING GREEN NETWORK FROM AN URBAN PLANNING PERSPECTIVE

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ABSTRACT

From the theoretical context of Smart City various studies have emerged that adopt an analytical approach and description of urban phenomena based on the principles of "network design"; this line of research uses the network systems theory to define the principles that regulate the relationships among the various elements of urban sub-systems in order to optimize their functionality. From the same theoretical basis, urban greenspaces have also been studied as networks, by means of the creation of models capable of measuring the performance of the system in its entirety, posing the basis of a new multy-disciplinary research field called green network. This paper presents the results of research aimed at clarifying the meaning of green network from an urban planning perspective through a lexical analysis applied to a textual corpus of more than 300 abstracts of research papers that have dealt with this topic over the last twenty years. The results show that the concept of green network appears still fuzzy and unclear, due to the different meaning given to the term "green" and to an incorrect use of the term "network", often referred to as a generic set of natural areas present in a city, without any reference to the network system theory or to the basic rules linking these elements together. For this reason, the paper proposes a unique definition of green network from an urban planning perspective that takes into account the contribution of other research areas to effective green infrastructure planning. This is the concept of "urban green network design" defined as "an urban planning practice, supported by decision support tools able to model green infrastructure as network, composed by natural and semi-natural areas, whose connections are modelled according to specific variables, in order to deliver an equal distribution of public services for enhancing the quality of life as well as a wide range of ecosystem services".

KEYWORDS:
Green network; Urban greenspace; Ecosystem services; lexical analysis.

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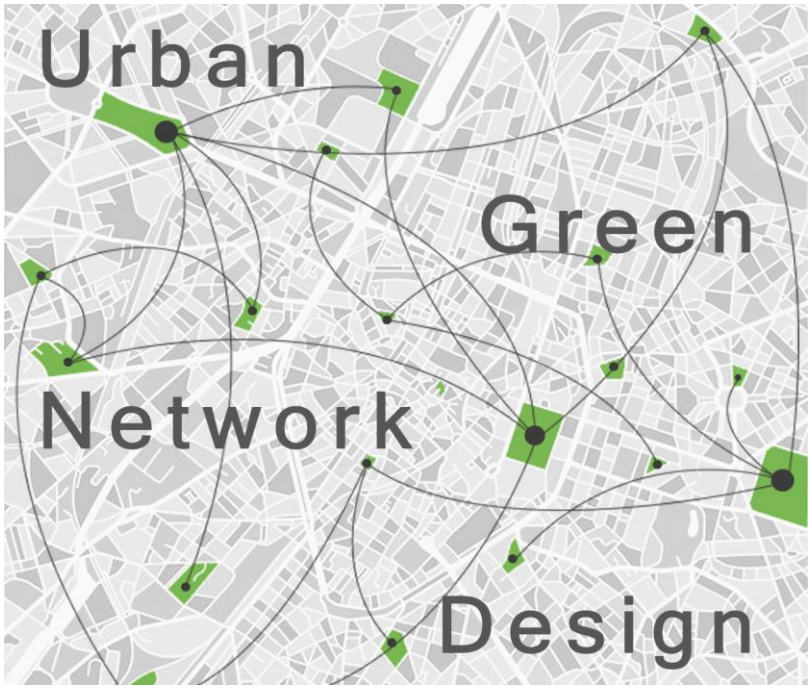

城市绿地网络设计：

从城市规划视角定义绿地网络。

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摘要

各种以“智慧生活”理论为背景的研究示例层出不穷，大部分研究都以“网络设计”原则为基础采用解析法和城市现象说明的方法进行；这一系列研究都使用了网络系统理论对调节不同城市子系统之间关系的原则进行定义，以尽可能优化各系统功能性。以相同理论基础为起点，学者们还将城市绿地空间作为网络进行研究，通过创建能够测量系统整体性能，构成一个被称为“绿地网络”的崭新跨学科研究领域。本文对研究的结果进行分析，旨在从城市规划角度入手，通过对 300 多篇近二十年来与本主题相关的研究报告的文本本身进行词法分析，阐明绿地系统的真正含义。结果表明，由于众人对“绿”一词的定义不同且对“系统/网络”一词使用不当，绿地系统的概念依然模糊不清，常常被解读城市中的自然区域统称，从未提及网络系统理论及与这些元素相关的基本规律。因此，本文从城市规划的角度出发，同时考虑其他研究领域对绿色基础设施规划的积极作用，提出了独特的绿地网络定义。这个“城市绿地网络设计”概念被定义为“以可将绿色基础设施建模为网络的决策支援工具为支持，由关系建模根据具体变量而定的自然和半自然区域组成，旨在提供提升生活质量及众多生态系统服务等公共服务的公平分配的城市规划实践”。

关键词：
绿地网络、城市绿地、生态系统服务、词汇分析

1 INTRODUCTION

In recent years, urban studies have begun to employ ecological rationality in planning cities and have therefore introduced techniques, methods and tools to integrate natural elements within the urban environment as part of the whole complex urban system. Consequently, Green Infrastructure (GI) has come to play a decisive role in redefining urban growth in many cities through a genuine green structural integration with the build environment (the creation of urban gardens in wooded areas, habitat for wild animals, ponds and wet areas, in addition to natural and artificial corridors of vegetation.) On a territorial level, GI may be conceptually defined as a 'green corridor' with a high level of bio-diversity (Jongman, Pungetti 2004; Bennet & Mulongoy 2006), while on an urban level this is conceived as a network created through strategic interventions, including a wide range of greenspaces and other elements of environmental importance (Aly & Amer, 2010); while green corridors have a purely environmental protection value, GI is characterized by its multi-functionality (Li et al., 2005). This leads to a wider perspective that entails the redefinition of anthropic systems and their relation with the urban structure in terms of ecological functions (Ahern, 2007). The EU commission defines GI 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 such as water purification, air quality, space for recreation and climate mitigation and adaptation" (EU Commission, 2017).

GI can be, therefore, defined as an element that enables the development of ecological relations between the city and its environmental context, whilst catering for social needs that are fundamental for the attainment of a high standard of urban life. Over the past few years, to this function has been added the recognition that greenspaces are effective tools in combatting the impact of climate change especially in terms of mitigation and adaptation policies (Matthews et al. 2015; Salata & Yiannakou, 2016). The idea is that the location and dimension as well as the intrinsic features of greenspaces (use of vegetation, functionality, the permeable/impermeable surface ratio etc.) depend on their interaction with other social, economic and geometric characteristics of the build environment (Gargiulo & Zucaro, 2015).

In order to manage the complexity of the relations mentioned above, in the last few years scientific and technological research in the field of urban studies has started to use research findings in the latest developments in network modeling (Ding et al., 2015; Fichera et al., 2016; Velásquez et al., 2017). Networking with its many variants, is one of the most active research areas in computer science involving researchers from System, Networks, Algorithm Design, Graph Theory. According to this theory, a network is a simplified representation that reduces a system to an abstract structure. Through the studying of these models, it is possible to gain insight into the nature of individual components (i.e. vertices), connections or interactions between those components (i.e. edges), as well as the pattern of connections (i.e. network). Any modifications of the structure (or pattern) of any given network can have a significant effect on the behavior of the system it depicts. Such models are starting to be used from outlining the fundamental concepts of urban development to the description and optimization of both physical networks, such as power, water or telecommunications, and human interactions within cities, with particular applications in quality of life and the flow of people and goods. Within this theory, the natural environment could be modeled and managed as a network, thus creating a new research field called green network design. This perspective appears realistic due also to the recent advances in digital geographic information which are fostering innovation in urban and regional planning (Massa & Campagna, 2014).

By reviewing the various research findings which have focused on this subject, it is evident that these theories, when applied to the concept of green network, are still in an experimental phase. Even from a conceptual point of view there is some debate as to the proper application of this approach in the wider field of intelligent, sustainable cities (Salvati et al., 2013). This applies also at a semantic level where the definition of green network has a different meaning according to the point of view of the respective discipline.

Based on these premises, this work intends to define on a purely scientific level and from the analysis of different scientific papers, which deal with the role of greenspaces in urban planning in general and the use of the green network concept in particular, the current developmental stage of this approach and its possible future applications with respect to the following questions:

- What are the principal functions implied by greenspace within the urban system?
- Is there any relationship in the current debate between the concept of green network with the network system theory?
- What is the contribution of different disciplines to the definition of the concept from an urban planning perspective?

2 DATA COLLECTIONS AND METHODOLOGY

In order to respond to the above questions, a textual corpus of more than 300 selected abstracts of scientific papers were analyzed by using lexical analysis tools. It has allowed the extraction of the main semantic dimensions of the discussion in order to highlight the current meanings and related fields of application of the green network concept, especially from an urban planning perspective.

For the application of the method a data collection was carried out in two different steps:

- collation of the abstracts of the most cited scientific papers in the field of urban studies over the last 20 years with green as the main topic;
- selection of those containing specific reference to the green network concept.

The abstracts were collated and organized by using the following selection and data process phases:

- journal selection: Selection of the main scientific journals in the field of urban studies according to the ranking of the two main scientific databases available on line, http://www.scimagojr.com/ and https://scholar.google.it/;
- download of data: By using web of knowledge database, the first 20 papers for each selected journal, filtered using "green" as main topic key and ordered by number of citations, were downloaded in the .csv file1 format;
- data processing of the csv file: The collated information was systematized in a spreadsheet table, organized in the following columns: 1. Title of the paper; 2. Authors; 3. Year of publication; 4. Abstact; 5. doi reference.

This data was analyzed with the Lexical Correspondence Analysis (LCA), an analytical tool capable of detecting the latent meaning in a group of texts; it is mainly based on "differences" and not on "measures" (Trobia, 2005); in other words, a term is all the more significant as it is specific to certain groups of texts. The software SPAD was used to analyze these connections and to break down the lexical table in a series of factors, each of which represents an aspect of the latent type of association present in the data. The process of analysis used is explained in the paper Less Smart More City (Papa et al., 2015); in this case the modes are represented by the years of publication, grouped on the basis of number of papers selected. In this way, the analysis allowed us to verify if the role of greenspaces in urban planning has been evolving towards specific topics within the scientific community and to extract the main concepts characterizing the steps of this evolution over the last 20 years.

By filtering the abstract in the obtained table, just 4 of the selected papers explicitly referred to the green network. For this reason, a further data collation was conducted like the previous one by using "green network" as the main topic key, and broadening the collection of abstracts to other disciplines, in order to understand

[1] Not every selected records contained the paper abstract as downloadable info in the csv file. For this reason some papers were not considered in the study.

the connections among disciplines concerning this concept. Therefore, a new column was added to the resulting spreadsheet table related to the research area of each selected paper. For this group of texts, a network text analysis was carried out using a free online software tool available on the website textexture.com; this tool visualizes any text, or group of texts, as a network and enables one to use this interactive visualization to read through the text in a non-linear fashion. Using the network, one can see the most relevant topics inside the text organized as distinctively colored clusters of nodes, their relationship to one another, and the most influential words - those responsible for topic shifts - inside the text. The resulting node-edge structure is encoded in a graph format and is processed by Gephi server-side Java toolkit, which calculates the basic metrics and applies community detection algorithms to the graph. If we imagine the scientific community as a network of scientists dialoguing through their papers, a word that is in a position which permits direct contact with many others can be considered as a major channel of information; in a certain sense, it represents the focal point of information flow in the network.

3 RESULTS AND DISCUSSION

3.1 LEXICAL CORRESPONDENCE ANALYSIS: EVOLUTION OF THE GREEN SPACES ROLE IN URBAN PLANNING OVER THE LAST 20 YEARS

Based on the technique of analysis of LCA results described in the paper Less Smart More City (Papa et al., 2015), one can see quite clearly the evolution of the concept over the last 20 years, especially along the first axis (fig. 1).

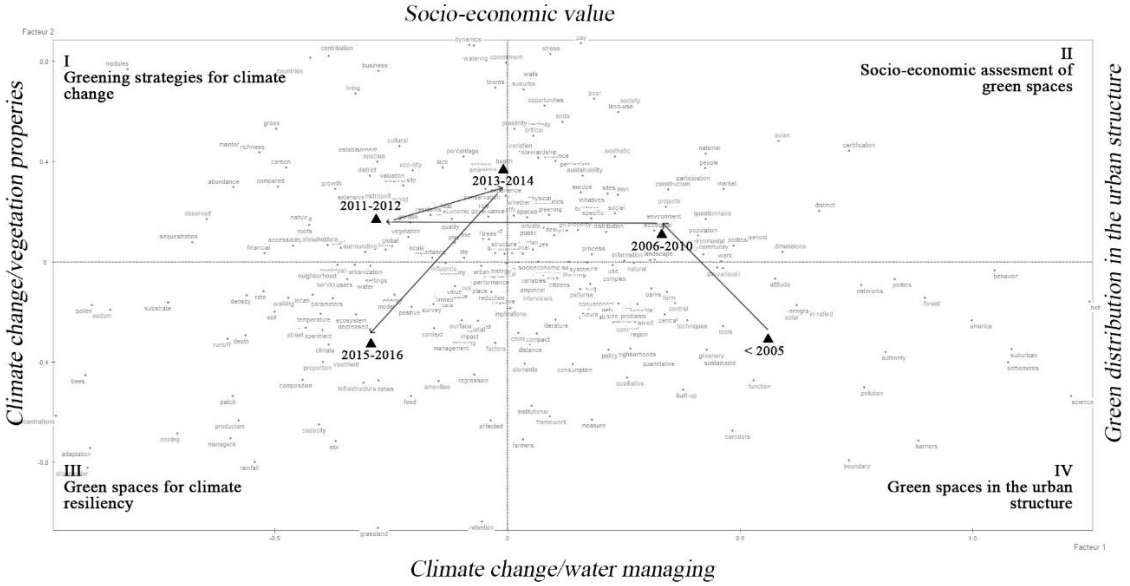

Fig. 1 LCA result describing the evolution of the concept of *green* within the most cited articles of urban studies journals over the last 20 years

In particular the scientific debate prior to 2005, concerning the role of greenspaces in urban planning, represented by the group of papers located in quadrant IV (*green spaces in the urban pattern*), seems to be characterized by greater attention to their spatial location in the urban pattern conceived as public space connecting different parts of the city; the presence of words like *belt, suburbs, politics, settlement*, characterizing the right hand side of the first axis, in fact, refers to the growth of urban centers and the related spatial planning solution especially in the growing suburban areas; at the same time, the presence of words

like *cooling, effect, lowering* represents the first signs of interest in greenspaces as elements to mitigate the effect of the urban heat island.

The necessity of new interventions in the existing urban patterns characterizing most of the cities, that appears an inadequate response to the catastrophic vision of climate change forecasts (IPCC, 2014), and the simultaneous economic crisis, that reduces the economic possibility of local governments to address adequately the security and emergency response needs, increase the number of papers addressing the topic of the economic value of the green spaces; therefore more studies, in the group of papers written in 2012 and 2013, use an approach based on the evaluation of green infrastructure in terms of economic benefits, by comparing the costs of green practices to "hard" infrastructure alternatives, the value of avoided damages, or market preferences that enhance value, such as property value.

Finally the last group of papers (2014-2015) is characterized by two different sets of terms:

- the first one, characterized by words like *adaptation, stormwater, cooling*, is clearly connected with the urban resilience concepts, thus confirming the growing interest in this topic and the main role of greenspaces in adaptive planning policies. Greenspaces became important planning elements to manage flooding with infiltration-based practices, prepare for drought by infiltrating water where it falls, reduce the urban heat island effect by planting trees (Inostroza, 2014; Gargiulo et al., 2016, 2017) and building green roofs, lowering building energy demands by reducing indoor temperatures and shading building surfaces (Gargiulo & Tulisi, 2016), using less energy to manage water by reducing rainwater flows into sewer systems (Zhang et al., 2015) and protecting coastal areas with living shorelines, buffers, wetlands, and dunes to help reduce coastal erosion and storm impacts;
- the second one, strictly connected with the previous one and characterized by words like *bees, pollen, organic, watering, substrate*, refers to the inherent characteristics of ecological systems working together and within the whole urban system. It shows a pronounced interest in other disciplines, such as biology, hydrology, and ecology (Brunetta & Voghera, 2014): the biodiversity of urban ecosystems, characteristics of vegetation, fauna and soil, have become part of the urban planning debate.

In the middle of the word cluster, the most transversal topics, characterizing the whole corpus of text, are present. It shows that concepts such as *accessibility, health, air pollution, quality of life,* are constantly present in the scientific community debate throughout the analyzed period.

Summing up, the current scientific panorama shows an increasingly fragmented framework concerning the issue of greenspaces in urban planning, motivated by the necessity to include new parameters to describe and design green infrastructure, and to discover new scientific evidence as to the relationship between natural processes of nature and the relative effects on the build environment, particularly in respect to the increasing attention given to the consequences of climate change.

3.2 NETWORK TEXT ANALYSIS: TOWARDS A DEFINITION OF GREEN NETWORK FROM AN URBAN PLANNING PRESPECTIVE

In this complex panorama of scientific research about the role of the greenspaces in urban planning, the necessity emerges of discovering new methods and tools to design and localize these spaces in the urban system according to the challenges that cities are facing. In this perspective, greenspaces are increasingly considered as nodes of a wider network interacting with the urban system. This is why the term "green network" is becoming part of the vocabulary of different research areas.

By analyzing a group of texts with "green network" as main topic through lexical analysis tools, it was possible to provide insight to the other two main questions placed in the introduction:

- Is there any relationship in the current debate between the concept of green network with the network system theory?

– What is the contribution of different disciplines to the definition of the concept from an urban planning perspective?

By simply collating the papers with "green network" as the main topic in the last 20 years from the Web of Science database, and categorizing them according to different research areas, firstly one can observe that the term green network recurs in a large amount of papers in the research areas of Telecommunications, Computer science and Engeneering, and is still little used in the fields of urban studies, ecology, geography and business economics (fig.2). Just considering this data, it would seem that, in the last few years, the concept of green network has become an important topic for the first group of disciplines, focused on the creation of tools, theories and methods to model the natural environment as a network; while, on the other hand, the second group of disciplines seem to start integrating these findings within their field of research.

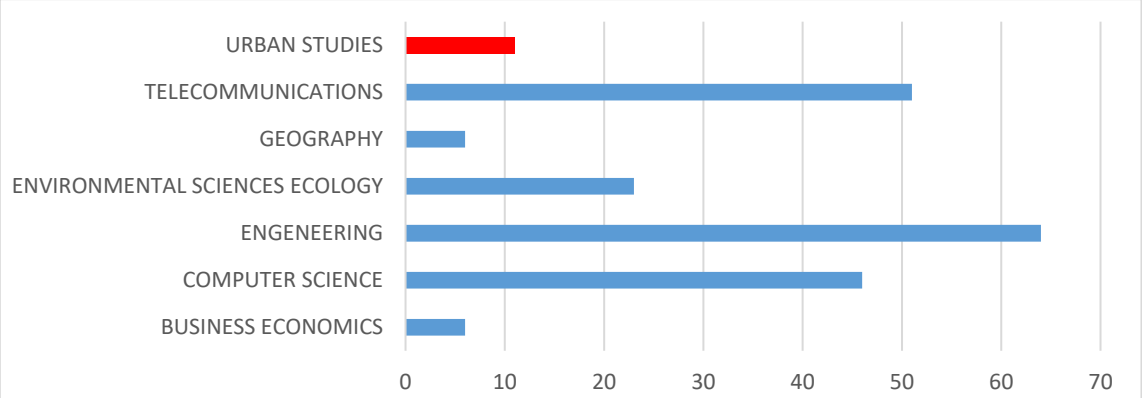

Fig. 2 Number of scientific papers written in the last 20 years, indexed on web of science, with "green network" as research topic key per different research areas

Thanks to a deeper analysis of the content of the papers, carried out with a network text analysis tool, a first disambiguation of the term appears clear, thus contradicting the above-mentioned hypothesis. In fact, by analyzing the most influential keywords per group of texts belonging to the different research areas (tab.1), the different meaning of the term becomes clear for the two main research areas groups:

Group 1 is composed of Urban Studies, Geography and Environmental Science Ecology research fields. In this case, the term is clearly related to the function of greenspaces in the urban context. Group 2 is composed of Computer Science, Telecommunication and Engineering research fields.

Research Area	1st Keyword	2nd Keyword	3rd Keyword	4th Keyword
Business Economics	Green	Network	Product	System
Geography	Urban	Green	Greenspace	City
Urban Studies	Urban	Green	City	Area
Environmental Science Ecology	Green	Network	Urban	City
Computer Science	Network	Energy	Power	Consumption
Telecommunications	Network	Energy	Power	Consumption
Engineering	Network	Energy	Power	Consumption

Tab. 1 Network text analysis results: most influential keywords per research area

In this case, the term is fundamentally connected with the reduction of energy consumption through the optimization of the power network (Matke et al., 2016); the term "green" has an evocative meaning, which

brings to mind the clean air of natural green landscapes in contrast to the gray polluted air due to the excessive use of carbon-based fuel for energy production.
Business Economics research field differs from the two groups. In this case, the term "green network" seems to refer to the analysis of eco-oriented economic product systems.
It suggests that the network theory coming principally from the Computer science field is still not used to defining the greenspaces strategy in urban planning. This is confirmed also by the number of studies about green network in the field of Urban studies, belonging also to other research areas according to the web of science classification (fig.3). The major contributions to the discipline of urban studies on the theme of the green network seem to come from the field of Urban Geography and Environmental Sciences Ecology.

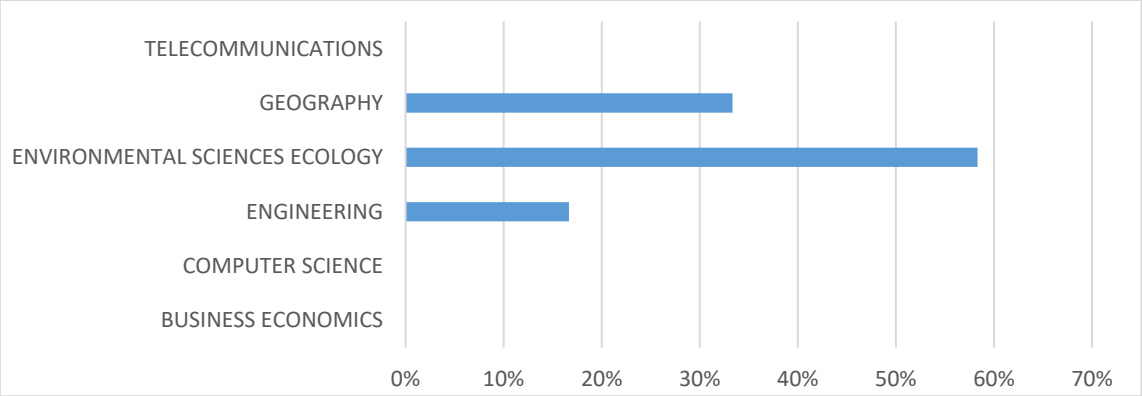

Fig. 3 Percentage of papers with "green network" as main topic in the field of Urban studies belonging also to other research areas according to web of science classification

For this reason, a deeper analysis was carried out considering the first group in order to understand better the main contexts in which the concept of green network is used for research areas and the main contribution of other disciplines in the field of urban studies. The Business economic field was also analyzed in order to understand in greater detail if the concept of green network represents an unequivocal discussion topic for the decision makers of public administrations.
In particular, the analysis of the most influential contexts and the related network was carried out by using the network text analysis tool available on the website textexture.com (Fig.4).
By interpreting these results, it was possible to extract a different definition of green network according to the content of the most influential contexts for each research area:

- **Geography:** The first context defines the scale of intervention (*city, area)* and the topic (*green, planning)*, the second one, the scope (*urban*, *future development)*, the third, the elements of the analysis (*plan, greenspaces, quality)* and the fourth, the approach used to analyze the characteristics of the elements (*ecological, base)* and the relationship among them (*network, system)*. The graph shows that four contexts are very interconnected, thus giving the possibility to suppose a single definition to the meaning of green network in this research area. To sum up, we can conclude that green network mainly represents a strategic element in urban structure for a sustainable future of cities (Li et al., 2005) through an approach that takes into account the quality of greenspaces (Moseley et al.2013) connected in a network (Frazier & Bagchi-Sen, 2015) and based basically on ecological principles (Jim & Chen, 2003);
- **Business economics:** In this case the contexts are not as clear as the previous ones. The main theme of urban ecology (*urban, ecological, green)* seems to have different and unconnected approaches (shown by the minimal amount of mutual interconnection among the terms of the different context). The first (*network, system, culture, development)* is connected with the green network culture for an ecology

system within the wider field of network culture in the information age, with the main goal to augment the eco-city notion (Xie & Zang, 2008); the second (*product, externality, environmental, brown)* refers to the cost benefit analysis of a green product network as opposed to the brown one (Brécard, 2013); the third (*greenspace, landscape, station)* refers to the integration of greenspaces in public transport strategies;

- **Urban Studies:** The first context defines the main boundaries of the corpus in terms of scale (*urban*, *area*), main elements (*greenspaces*) and main action (*greening*); The second context refers to the use of the green network as the main element for city planning strategies (*city, strategy*) for sustainable development (*environmental, development*). The third context shows a clear intent to include specific notions of natural science (*specie, corridor, forest, level*) in public policies; the fourth context refers to the interaction of the green infrastructure (*green, network*) with the urban system (*space, system*). To sum up, we can conclude that in the research area of urban planning green network is mainly considered as a system of elements characterized by ecologically based relationships interacting with the other urban systems (Jim & Chen, 2003; Mahmoud & El-Sayed 2011; Oh et al., 2011);
- **Environmental Sciences Ecology**: The presence of the terms *green* and *network* in the first context underlines the centrality of the theme in this research area, while the terms *city* and *area* define its application to the specific context of urban environment. By analyzing the dimension of the circles, representing the between centrality of these words, the graph (fig.5) reveals that they are "the most connective" words in the analyzed group of text; it means that all the other contexts are strictly connected with the first one. From this perspective, the second context shows that ecology science uses the same principles applied to larger ecosystems (*landscape, forest*) to describe natural science phenomena on an urban scale (Weller & Ganzhorn, 2004; Ouin et al., 2008; Hladnik & Pirnat, 2011), and that the latter are studied as networks (Yang et al., 2015). In the third context, a specific insight into this field emerges in the relationship between the characteristics of green spaces (*greenspaces, quality*) and their position in the urban pattern (*urban, land*) (Jim, 2013). By reading the terms contained in the fourth context, it can be seen that many papers in this research area propose analytical methods (*methods, analysis*) to evaluate green infrastructures (*GI*) in terms of network (Kang & Kim, 2015). Summing up, this research area appears to have the highest degree of maturation in the green network concept, thus producing a more in-depth analysis of method and tools in order to evaluate the effectiveness of green infrastructures in a specific urban context;

By comparing the results of specific research areas, some observations can be made about the above-mentioned findings:

- the green network concept in general, and in the fields of Urban Studies and Business Economics in particular, still appears fuzzy and unripe;
- the Environmental Science Ecology research area seems to give the main contribution to the definition of the green network concept, due to the presence of a terminology typical to the ecology vocabulary in all the main contexts of the analyzed groups of text;
- the role of greenspaces as public spaces able to enhance quality of life in terms of accessibility and human and environmental health, and the proven central role of green infrastructure in climate change mitigation and adaptation strategies don't appear clearly in any of the analyzed main contexts; it could mean that, in relation to these issues, greenspaces are still far from being conceived as networks; another hypothesis is that they are considered not as an independent network but as a functional part of wider ones;
- the lack of terms in Business Economics research area dealing with the consequences on the real estate of urban greening strategies, appears in contrast with that stated in the previous chapter in which the

economic value of green spaces is one of the main topics of the scientific community in the field of Urban Studies over recent years. It means that green network is not considered as a concept to describe the distribution of greenspaces in the urban pattern; it is seen to be more connected to the ecology culture network and to the green product market;

– in the urban studies research area, green network seems to be a synonym of green infrastructure with few elements related to the network system theory.

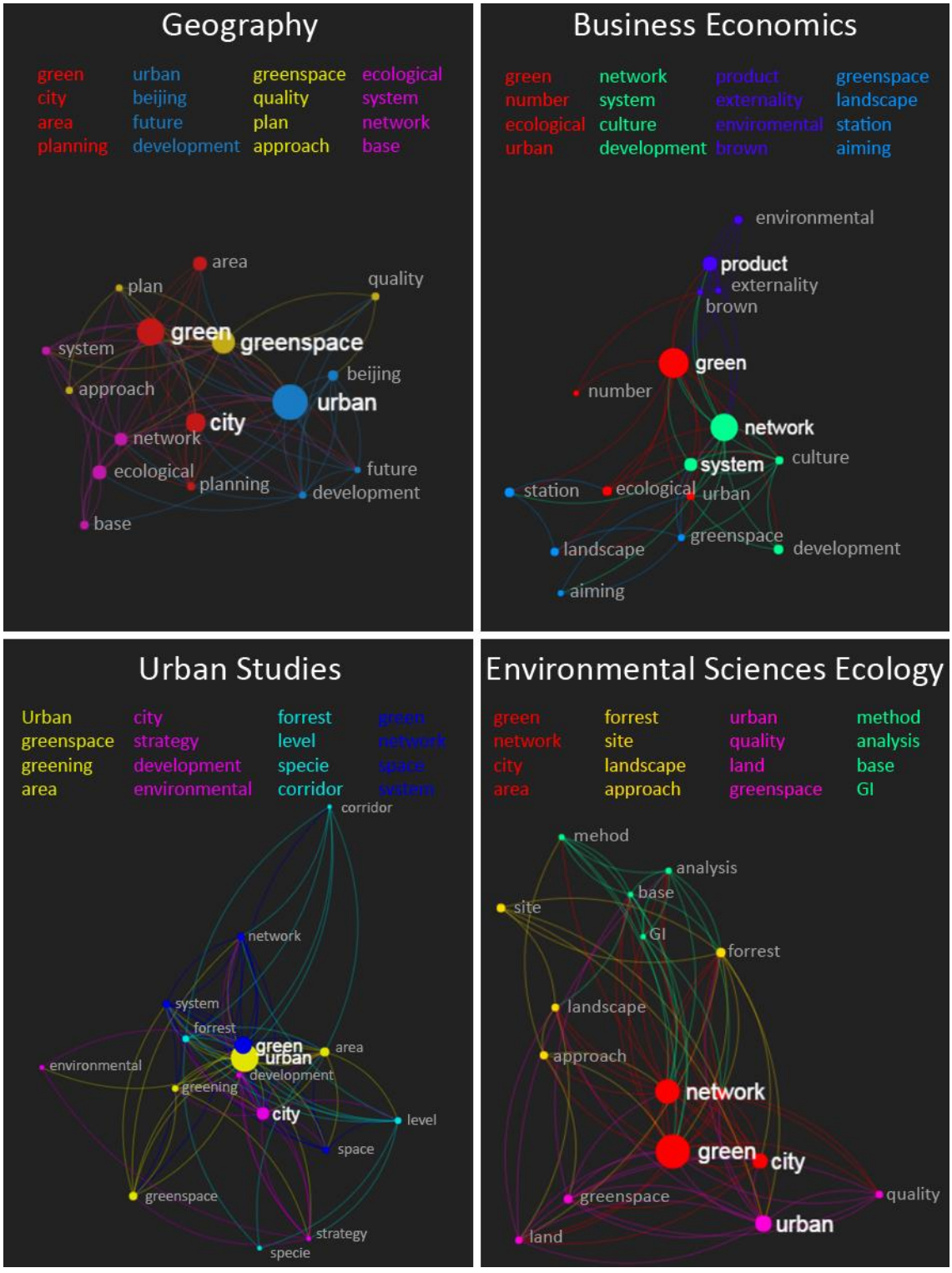

Fig. 4 Network text analysis results: most influential context per research area

4 CONCLUSION

Extensive urbanization has made the complexity of cities greater than ever before. For this reason, a new "science of cities" is emerging in the scientific debate and increasingly advanced mathematical models, especially networks ones, have been developed in order to describe and optimize both physical networks, and human interactions. From this perspective, natural environment elements in the urban patterns could also be modeled and managed as networks, by amalgamating findings in natural and social sciences within a multidisciplinary approach. Therefore, the increasing attention paid to the different roles the greenspaces could have for a sustainable development of urban areas, together with the above-mentioned networking theories applied in urban studies, has led the scientific community to include the green network concept in its vocabulary.

Nevertheless, by analyzing the results of the present study carried out with lexical analysis tools, it emerges that the meaning of the concept, from a semantic point of view, is still fuzzy and unclear. The reason for this confusion is due firstly to the meaning of the two terms included in the concept: green and network. In some research areas the term "green" is used in its evocative meaning, to define products, strategies or processes which bring to mind the concept of sustainable development based on living conditions and resource use meeting human needs without undermining the integrity and stability of the natural systems. From this perspective, the green network concept can be referred not just to the urban natural areas system but also to other groups of interconnected elements such as systems for controlling energy storage devices in power networks with a high share of fluctuating renewable energy sources, or even consumer networks for environmentally oriented marketing strategies. For this reason, a Lexical Correspondence Analysis (LCA) was carried out just considering scientific papers published over the last 20 years in the principal urban studies journal with *green* as main topic key; it shows that the debate on the function of greenspaces in urban studies is still very lively and an ongoing process characterized by a growing use of terms coming from different disciplines such as economy, ecology, geography etc. Therefore the term *green* related to the city doesn't describe greenspaces just as public services but in a wider perspective of ecosystem services, thus opening the debate to new scientific evidence concerning the relationship between ecological processes of nature and the relative effects on the build environment, especially important due to the increasing attention given to the consequences of climate change.

This open discussion of the different functions attributed to the natural areas in the urban context, has probably led to an incorrect use of the term *network*, whose general definition is "system consisting of many similar parts that are connected together to allow movement or communication between or along the parts". It becomes clear from further analysis, carried out with network text analysis techniques, applied to a restricted group of scientific papers clearly related to the system of natural and semi-natural areas in the urban context. In fact, from the analysis of the results, the term *network* seems to be referred to as a generic set of natural areas present in a city, without any reference to the network system theory or to the basic rules linking these elements together, except for the ecological field, that uses the same principles applied to larger ecosystems to describe the relations among *green elements* on an urban scale and evaluate the ecological effectiveness of green infrastructures in a specific urban context.

To sum up, it is evident that green network concept cannot yet be considered as a defined topic in urban planning. To avoid any form of disambiguation, and to provide a unique definition of the terms from an urban planning perspective, we might talk about *urban green network design* defined as an urban planning practice, formulated by decision support tools able to model green infrastructures as networks, composed of natural and semi-natural areas, whose connections are modelled according to specific variables, in order to deliver an equal distribution of public services for enhancing the quality of life as well as a wide range of ecosystem services. From this perspective, the green network concept could open a multi-disciplinary field of research

which combines natural and social science with computer science findings, in order to provide public administration with tools able to evaluate consequences of their choices in terms of accessibility to public services and urban resilience.

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IMAGE SOURCES

Fig. 1, 2, 3, 4: elaborated by the author

Tab. 1: elaborated by the author

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