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Cities Resilient to Climate Change through Natural Heritage: a Bibliometric Review †

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Abstract: Natural heritage is the composition between biodiversity and geodiversity; therefore, it is also a primary source of ecosystem and geosystem services that have multiple benefits such as adaptation to climate change. However, it is mainly found in natural environments. On the other hand, due to climate change, there are cities around the world with extreme conditions such as heat or cold waves. The aim of this article is to analyse the implications of climate change in urban areas through a bibliometric mapping of ecosystem and geosystem services in urban planning of cities for the use of natural heritage as control and development of cities. The methods are indicated in a) selection of the topic, keywords and scientific databases; b) pre-processing, merging of databases, and data processing using Bibliometrix-RStudio; and c) analysis and interpretation of results. A total of 1425 records were found in Scopus and 1839 in the Web of Science, and the countries contributing to the subject are the United States (54%), China (52.2%), Germany (18.4%), the United Kingdom (17.8%), and Italy (15.8%). In addition, the processing of the unified database made it possible to recognize i) conceptual and intellectual structure, research trends over time. Finally, geosystem services and ecosystem services help mitigate climate change through green infrastructure, blue infrastructure, and their adaptability to gray infrastructure, contributing to sustainable development goals: sustainable cities and communities and climate action.

Keywords: green infrastructure; blue infrastructure; sustainable city; scientometric analysis

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1. Introduction

Natural diversity is the intersection and interaction between biodiversity (related to biotic variation [1]) and geodiversity (related to geo(mor)logical variation [2,3]) [4,5]. It is also associated with natural heritage and megadiverse places, i.e. it is found in natural environments [6,7]. Its importance lies in the benefits it brings to humanity in a context of environmental sustainability, composed of the ecosystem and geosystem services [8,9]. These include adaptation to climate change, energy, food, water, air, and pandemic prevention, among others [10,11]. On the other hand, climate change is the change in weather patterns [12], caused by the excessive emission of greenhouse gases from various industrial activities [13,14]. Climate change causes problems such as extreme weather conditions like heat and cold waves, hurricanes, tornadoes, landslides, and erosion, which affect cities and, in general, the sustainability of the world's population [15,16]. For example,

in Asia, cities such as Bangkok (Thailand), Seoul (South Korea), and Singapore are vulnerable to climate change, mainly due to heat waves and floods [17]; in Southeast Asian cities, Kamput (Cambodia), Hoi An (Vietnam) and Samut Sa-khon (Thailand), rban transport is threatened by sea level rise, storm surges, water intrusion, and the effects of flooding [18]. In Europe, coastal cities bordering the Mediterranean, e.g. Zagreb, Athens (Greece), Rome (Italy), Valencia (Spain), are prone to climate change impacts, including changes in the water cycle and desertification [19]; In addition, Vienna (Italy) and Salzburg (Austria) are affected by extreme weather affecting tourism and the economy of the cities [20]. In America, California (United States), climate change causes fires, floods, hurricanes, hurricanes, and other natural disasters [21]. In Sao Paulo (Brazil), this problem causes flooding and overflowing of rivers, affecting urban areas and the environment [22]. In Africa, Guateng province, fresh water is threatened due to climate change stress affecting sustainability and socio-economic activities [23], in Lagos (Nigeria), water resources, including groundwater, are vulnerable mainly due to overexploitation and decreases in aquifer recharge due to changes in climate [24]. In Australia, Sydney, climate change has decreased air quality and with it, deteriorating human health, even causing premature deaths [25]; In Brisbane, this phenomenon increases the temperature of the city, reaching 40°C, leading to dangerous heat [26].

Thus, the ecosystem and geosystem services play a key role in helping cities adapt to the various threats of climate change through green, blue and combined grey infrastructures [27]. Green infrastructures can be defined as constructions in an urban space that offer ecosystem benefits through green areas [28]. On the other hand, blue infrastructure includes benefits from water bodies such as rivers, lagoons, wetlands and seas in urban settings [29]. Both can be combined into a green-blue infrastructure (GBI), and the existing infrastructure can be adapted to a hybrid, i.e. greengray hybrid [30]. While these infrastructures bring benefits such as climate change adaptation, there are other benefits such as: improvements in public health, recreation and urban landscapes, water and air [31]. In general terms, ecosystem and geosystem services in urban environments offer benefits linked to the Sustainable Development Goals (SDGs) set out by the United Nations [32,33]. Thus, systematic analyses using bibliographic information, mainly from scientific databases contribute to the analysis and synthesis of different areas, such as urban sustainability [34], climate change mitigation and adaptation [35], and disaster risk management [36]. The aim of this article is to analyse the effects of climate change through bibliometric mapping of scientific publications in the Scopus and Web of Science (WoS) databases for the use of experiences about the natural environment as control and development strategies in cities.

2. Materials and Methods

The method in this research is synthesised in three steps, the first is about the selection of the topic and the scientific databases; the second about the (pre)processing and combination of Scopus and Web of Science (WoS); the third about analysis and interpretation. Step 1 consisted of selecting the topic and the databases, specifically the topic of natural heritage, eco- and geosystem services in urban environments, using keywords and Boolean operators: “natural heritage” or “natural diversity” or “ecosystem services” or “geosystem service”AND “city” or “urban planning” AND “climate change” or “climate adaptation” or “climate mitigation” OR “climate regulation”. Subsequently, this step included the selection of databases, specifically Scopus and WoS, because both databases index high quality articles [37]. Step 2 consisted of combining the databases, and removing duplicate documents in Scopus and WoS, i.e. documents shared in both databases [38]. This step also involved processing the unifying database in Bibliometrix-RStudio. This software is specific for science mapping studies [39]. Finally, step 3 allowed the results to be exported from Bibliometrix, mainly a) trends in published papers per year, b) percentage of contribution in country publications, c) conceptual structure and research trends (through keyword analysis), and their interpretation considering i) articles with the

highest number of citations, open access and mitigation strategies for the use of natural heritage and its benefits in urban environments.

3. Results and Interpretation

Overall, the interaction of search terms led to 1425 records in Scopus, in WoS 1839, the database with the merger of Scopus and WoS resulted in 2376 records, i.e., 888 duplicate records were removed. The trend of published papers per year is shown in Figure 2.

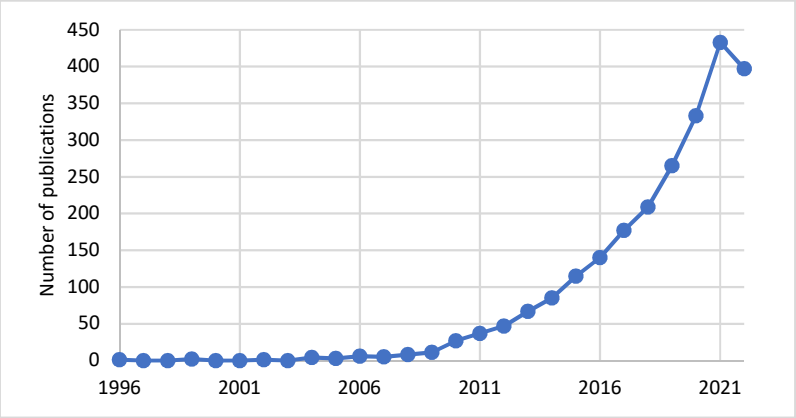

Figure 1. Number of publications per year (unified database, Scopus and WoS).

Two trends stand out, the first in a linear fashion from 1996 to 2009, and the second in an exponential fashion from 2010 to 2022. In the first period (1996 to 2009), the importance of nature for the survival of humanity and the need for ecosystem services in cities is recognised [40]. A primary option is urban forests, which offer multiple eco-systemic benefits such as climate regulation, soil protection, carbon dioxide abatement in the atmosphere [41]. In addition, the modelling of ecosystem services began, which enabled the development of climate change mitigation strategies [42]. In the second period (2010–2022), the links between ecosystems and social-ecological systems, which manage vegetation patterns and harness the benefits of landscapes in urban environments, are recognised [43], as well as the importance of forests as ecosystem services, mainly the water cycle and its availability [44]. It also substantiates the various benefits, mainly climate change adaptation, air purification, urban planning, that are obtained through green infrastructure, which together bring benefits for human well-being [11]. The term "Nature-based solutions" (imitates, copies or builds on nature) is highlighted [45]), which promotes green and blue infrastructures, involving research (natural environments in urban areas), government, politics and society [46]. Also the importance of the restoration of mangroves, sand dunes, salt marshes that in coastal cities prevent the effects of climate change (erosion and flooding) [47]. And it distinguishes urban environments with green infrastructure, which offers climate regulation, in general, low temperatures in summer [48]. On other hand, this analysis includes the countries with the largest share of contributions, where the United States (54%), China (52,2%), Germany (18,4%), the United Kingdom (17,8%) and Italy (15,8%) stand out.

3.1. Conceptual Structure and Research Trends

The conceptual structure was processed using the author keywords and exported from Bibliometrix. Figure 4 shows the conceptual structure grouping driving themes: cluster a (green infrastructure, urban planning, nature-based solutions); niche themes: cluster b (urbanisation, conservation, carbon sequestration); emerging or declining themes: cluster c (land use, land use change, values of ecosystem services); core themes: cluster d (ecosystem services, climate change, sustainability).

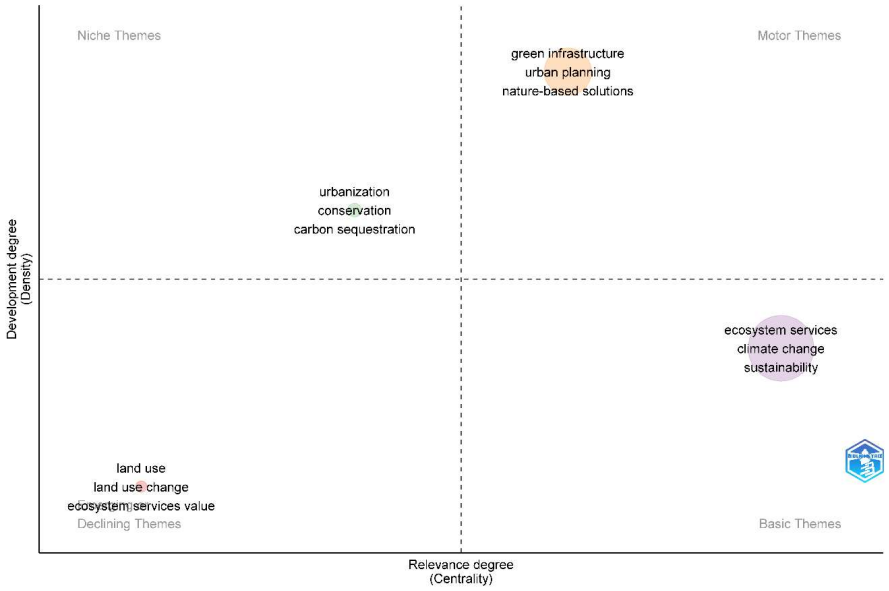

Figure 2. Thematic map about urban planning, climate change, conservation and land use change.

On the other hand, the research trends identified are shown in Figure 5, where the line represents the period of study of the keywords and the size of the node represents the frequency of use. The most studied trends are ecosystem services (621 uses), climate change (382), and green infrastructure (193). While those that have lasted over time are water supply (2011–2020), urban forests (2014–2020), land use change (2015–2020). Finally, the current trends are urban green spaces and investment.

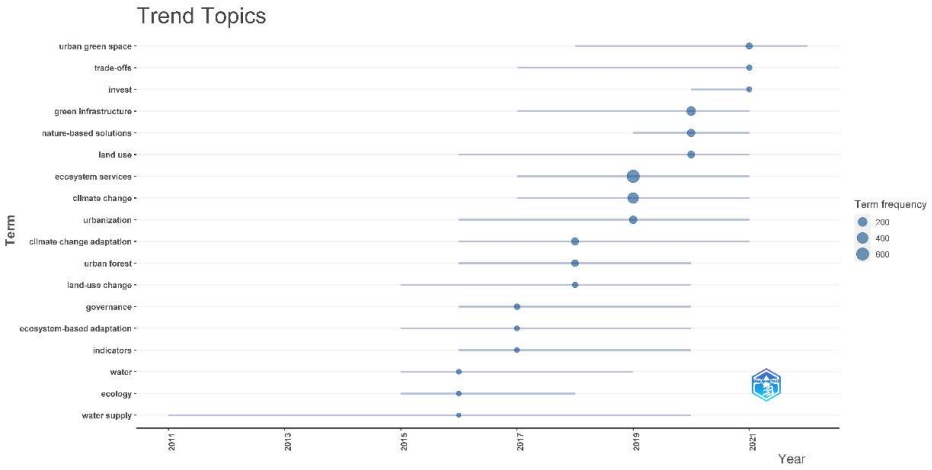

Figure 3. Research trends using authors' keywords.

3.2. Research Institutes, Themes and Sources

Overall, the institutes with the highest number of contributions in this topic are Chinese Academy of Science (n = 70), University Chinese Academy of Science (n = 67), Beijing Normal University (n = 61), Arizona State University (n = 58), US Forest Services (n = 58). Figure 4 lists the top 15 research institutions, topics and sources (journals, conferences and/or books). In which Sustainability (148), Science of the Total Environment (n = 98), Ecological Indicators (n = 72), Urban Forestry & Urban Greening (n = 71), and Land (n = 46) stand out.

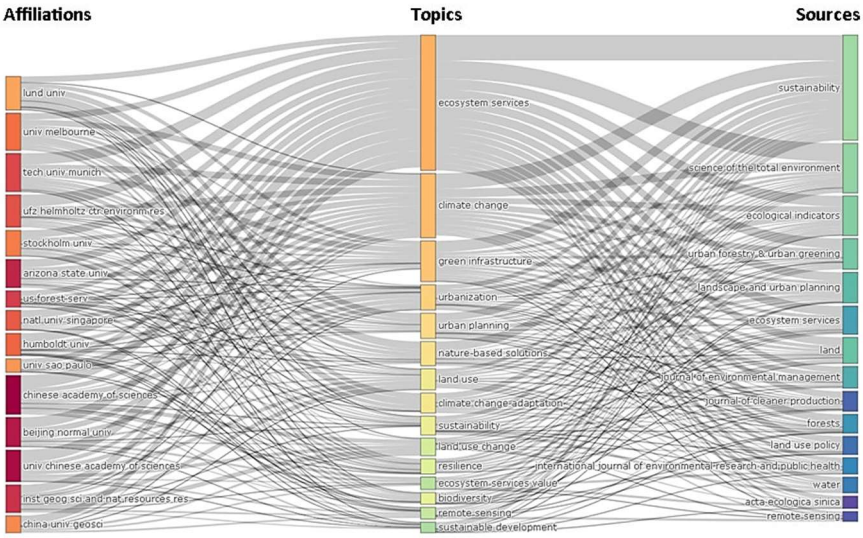

Figure 4. Links between Research Institutions, Topics and Sources (Sankey diagram).

4. Discussion.

The contributions collected by unifying the Scopus and WoS databases reached 2376 records (without duplicates), information that has been worked on by 7800 authors in 800 sources (journals, conferences, books). It also made it possible to identify the most studied trends: ecosystem services (621 = 26.13%), climate change (382 = 16%), and green infrastructure (193 = 8.12%). And that the countries with the highest contribution amounts are: United States (54%), China (52.2%), Germany (18.4%), United Kingdom (17.8%) and Italy (15.8%). In addition, the sources with the highest number of contributions were identified as Sustainability (148), Science of the Total Environment (n = 98), Ecological Indicators (n = 72), Urban Forestry & Urban Greening (n = 71), and Land (n = 46). In general, when comparing results with systematic studies, where ecosystem services are analysed, the trend of publications per year is very similar, as the shape of the trend starts in the 1990s [49], where exponential growth has been noted since 2010 [50]. Countries contributing to the development of the issue are also identified, with the United States leading the way [51]. Some advantages of the study are the unification of the Scopus and WoS databases, which helps to reach papers indexed in good quality journals. In general, the trends are: (i) publications per year, (ii) relative contribution per country, (iii) research trends over time through keywords, (iv) conceptual structure, and v) top universities and research institutes, relation to the topics addressed and sources (Figure 4). However, the main disadvantage is that in the review part only articles with the highest number of citations are considered.

5. Conclusions

The analysis of climate change mitigation through eco- and geosystem services in urban environments allowed the identification of benefits in these areas. For example, the study of 2376 records unifying the Scopus and WoS databases mainly identified the use of forests in cities that help in climate regulation and improve air quality. Also, the use of green and blue infrastructure, which together help public health in urban environments and offer the public benefits of eco- and geosystem services, mainly adaptation to climate change, carbon sequestration, and improve the attractiveness of the landscape and encourage recreation by taking advantage of the consideration of natural heritage in urban areas.

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