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URBAN GREEN EQUITY: OVERVIEW OF SCIENTIFIC RESEARCH FROM 1992 TO 2021

Wanda Maira Muniz Almeida*
Eliane Guaraldo[1]

Abstract: The growing concern with the impacts of climate change and the fast urbanization of cities has led international policies to guide changes in attitudes by governments and civil society, directing effective models of sustainable governance aimed at environmental health and equal access for society environmental benefits. In this study, we seek to understand the evolution of research and scientific production on a topic of great relevance today – green equity. Through scientometric analysis based on a systematic literature review, we analyzed articles published in the period between 1992 and 2021. We used the open source R-tool Biblioshiny, which processes information from academic databases to carry out the analyses. Through this methodology it was possible to identify the main fields of research and relate the results obtained with important historical milestones for sustainable development. We also seek to highlight the evolution of research lines and highlight the significant flows in the global collaboration network. We found that the theme of green equity was driven by international agendas such as the SDG and has been gaining more space in scientific production, linked to a greater variety of issues such as climate change, accessibility to green spaces, ecosystem services, green infrastructure and socioeconomic issues.

Keywords: Sustainable Development; Urban Governance; Climate Changes; Urban Forest; Biblioshiny.

* Autor correspondente

Architect and urban planner, Landscape Laboratory, Attending Master's degree in Natural Resources at Mato Grosso do Sul Federal University (Universidade Federal do Mato Grosso do Sul, UFMS), Pioneiros, Brazil. Email: wanda.almeida@ufms.br

1. Architect and urban planner, doctor in Urban Environmental Structures at University of São Paulo (FAU-USP), Landscape Laboratory, Post-Graduation Program in Natural Resources; Associated Professor at Mato Grosso do Sul Federal University (Universidade Federal do Mato Grosso do Sul, UFMS), Pioneiros, Brazil. E-mail: eliane.guaraldo@ufms.br

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EQUIDADE VERDE URBANA: PANORAMA DA PESQUISA CIENTÍFICA NO PERÍODO DE 1992 A 2021

Resumo: A crescente preocupação com os impactos das mudanças climáticas e da rápida urbanização das cidades tem levado as políticas internacionais a orientar mudanças de atitude por parte dos governos e da sociedade civil, direcionando modelos eficazes de governança sustentável orientados à saúde ambiental e ao acesso igualitário da sociedade aos benefícios ambientais. Neste estudo buscamos compreender a evolução da pesquisa e da produção científica de um tema de grande relevância na atualidade – a equidade verde. Por meio de análise cienciométrica baseada em uma revisão sistemática de literatura, analisamos artigos publicados no período compreendido entre 1992 e 2021. Utilizamos a ferramenta-R de código aberto *Biblioshiny*, que processa as informações das bases de dados acadêmicos para a realização das análises. Por meio desta metodologia foi possível identificar os principais campos da pesquisa e relacionar os resultados obtidos com marcos históricos importantes para o desenvolvimento sustentável. Buscamos também destacar a evolução das linhas de pesquisa e evidenciar os fluxos significativos na rede de colaboração global. Descobrimos que o tema da equidade verde foi impulsionado por agendas internacionais como a ODS e vem ganhando cada vez mais espaço na produção cientifica, vinculado a uma maior variedade de questões como mudanças climáticas, acessibilidade a espaços verdes, serviços ecossistêmicos, infraestrutura verde e questões socioeconômicas.

Palavras-chave: Desenvolvimento Sustentável; Governança urbana; Mudanças climáticas; Floresta urbana; *Biblioshiny.*

Urban green equity is defined by Nesbitt as the equitative access to urban forests, which management aims to mediate the urban population's capacity of obtaining ecosystem services associated to them (NESBITT; MEITNER; GIRLING; SHEPPARD, 2019). The concept has a close relationship to discussions about sustainable urban growth approached by global organizations and agreements among world leaderships.

UN, the United Nations, in its last World Cities Report, from 2020, disclosed an alert on the criticality and concern with the fast urbanization of cities, where it is estimated that until 2050, 70% of the world population will be living in urban areas. This estimate directly implies on the cities' quality, impacting the life of billions of people and several ecosystems around the world.

The sustainable urban development happens when the occupation aims to privilege the common good and reduce inequalities in order to balance social needs. Thus, in addition to including the population in its diversity of age, gender, race or any other characteristics, it is also necessary to distribute infrastructure, public spaces, goods and urban services in an equitative way.

Still in the second half of last century, with Stockholm Conference (1972), Vienna Convention (1985), Montreal Protocol (1987), Brundtland Report - Sustainable Development (1987) and, finally, Agenda 21/ Rio 92 / Eco 92 (1992), cities' development was the focus of discussions and agreements among world leaders. In 2000 the Millennium Summit (UN) started the Millennium Declaration, in which the nations committed to join strengths to reduce extreme poverty in 15

years, through eight Millennium Development Goals (MDG). When this period finished, in 2015 UN launched the Agenda 2030, with an action plan of 17 Sustainable Development Goals (SDG) and 169 global goals, and one of them is the universal access to public spaces that are green and safe, inclusive and accessible, thus reinforcing the importance of the use and distribution of the multifunction ecosystem services derived from green spaces.

In this context, a growing concern with the impact of climate change and fast urbanization puts urban forests as strategic infrastructure, frequently included in global and regional initiatives. In addition to that the ecosystem services and their connection to the urban green have been acknowledged as essential components to sustainable cities (STEENBERG; MILLWARD; DUINKER; NOWAK *et al.*, 2015).

Although the healthy environment is a basic human right, studies in the field of environmental equity established that a variety of harmful uses of the land is disproportionately located in neighborhoods with low income and minority populations (KOO; BOYD; GUHATHAKURTA; BOTCHWEY, 2019).

As of this context, we seek to explore how the academic research in green equity has evolved in the last 30 years, verifying through bibliometric analysis its main approaches, directions and possible future unfoldings. This period allows the identification of lines of important researches, emerging topics, periodics and most influent authors and points which are the connections globally existing in the field of urban green equity.

Methodology

The literature systematic reviews provide reproducible and reliable evaluations of the current state and a research field (ROY, 2012). In this study, we chose the Scopus database for the search of documents and selection of relevant literature in articles related to urban green equity. We used as search term the expressions "*green equity*" OR "*green inequity*" OR "*Environmental justice*" AND *urban* AND *environmental* OR *green* OR *forestry* OR *greenspace* OR *greening* for the time gap from 1992 to 2021. Firstly, the term search selected 975 documents, from which, after the title analysis, we limited to 495 articles that presented more adherence to the theme.

After the definition of the text corpus, we proceeded to the science-meter analysis. In Scientometrics there are several tools and softwares with important functions for the viewing and exploring process of networks. We used *Biblioshiny*, an open code R-tool for a broad research of the scientific mapping that includes the main bibliometric analysis methods. With it, it is possible to import bibliographical data directly from *Scopus* and perform bibliometric analyses building data matrices for coupling, scientific collaboration analysis and keywords analysis. Thus, we conduct a structures analysis and present the research overview in green equity. We go from the production and relevance of articles associated to time frames, identification of research lines and emerging topics based on semantical evolution (which consists on the relationship among the main keywords, authors and periodics distributed in time and consolidated in a *Sankey* diagram) and, at last, the main connections and relevance of the countries in the global scenario, where the number of publications and collaboration networks were considered.

Results

Scientific production and global milestones in sustainability

The general data that we presented on table 1 show the main quantitative information obtained from the *text corpus* selected. In this, the 495 articles analyzed are concentrated in the last 30 years and were published in 167 different periodics. We also indicate the average values of publications, citations and annual growth.

Table 1 - General information about the text corpus data

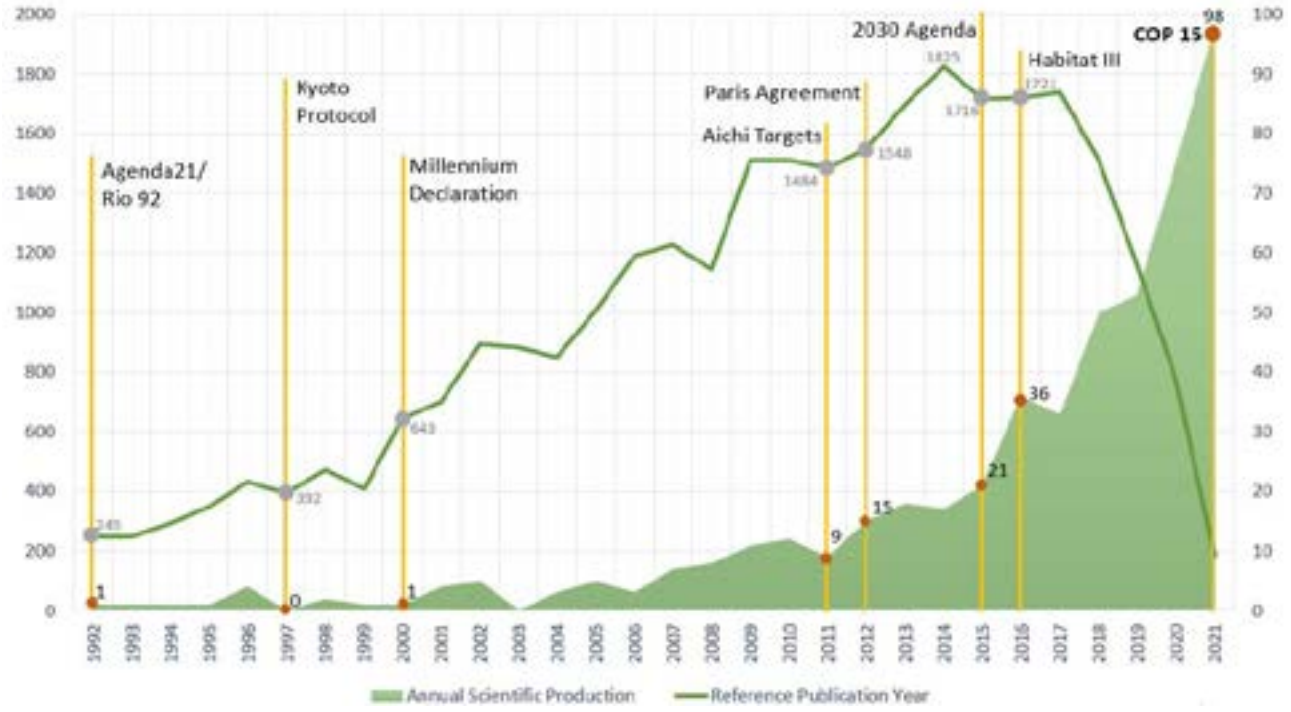
Period	1992 to 2021
Documents – Articles	495
Average years of publishing	4.79
Average of quotes by document	39.96
Average of quotes by year by document	6.137
Annual growth average rate	18,51%

Source: authors

According to the content analyzed, chart 1 (below) shows how this growth happened and which were the global milestones from 1992 to 2021. In it we see that the researches on the theme had numerically little significancy at the end of the twentieth century. This is probably due to the fact that the period is placed between the global agreements, such as Agenda 21, Kyoto Protocol and Millennium Declaration. Later, the growth happened in a gradual way until 2014, with a publishing average of 8.35 articles a year. In 2015, with Agenda 2030 and the creation of the Sustainable Development Goals, we see an elevated growth of the studies related to green equity, in which the average presented was of 48.5 articles a year. Considering the whole period researched, 1992 to 2021, the annual average growth rate was 18.51%.

The evolution of the number of quotes is similar to the growth of publications. This evolution was generally growing, pointing to a higher stability between 2009 and 2018, with a peak in 2014. For the publications posterior to 2018, we observed an accentuated decrease in the quantity of quotes, due to the time needed so that the new publications can become references in the area. However, we inferred that the theme has still not reached its maturity stage and, probably will continue to attract more researches as far as global actions intensify, as well as the theme disseminates through the countries.

Chart 1 - Publications and references associated to sustainability global milestones Font



Source: authors

Main research areas: keywords analysis

With the specific keywords analysis, it was possible to notice the main topics addressed in the researches as well as their development. Using *Biblioshiny*, we obtained a list of the 25 most used keywords by the authors. In Picture 1 we present this information in a word cloud shape, a visualization resource in which the themes relevance is categorized according to the font size, making the information clearer.

We noticed that the keyword "*environmental justice*", quoted 208 times, is highlighted. This happens because the term composes the pillars of the concept of green equity in its origin, even before the time period approached in the research. The second most frequent keyword is "*urban green space*" with 34 quotes, denoting an association between the green equity idea and the several urban places, spatializing the concept. Following, the word "*equity*", as a simple noun, appears 33 times, "*accessibility*" also 33 times, and "*urban planning*", 28 times. We understand that green equity is an expression that definitely starts to be associated to issues of space, urban space specifically and spatial distribution.

Picture 1 – Keywords Cloud

Source: authors

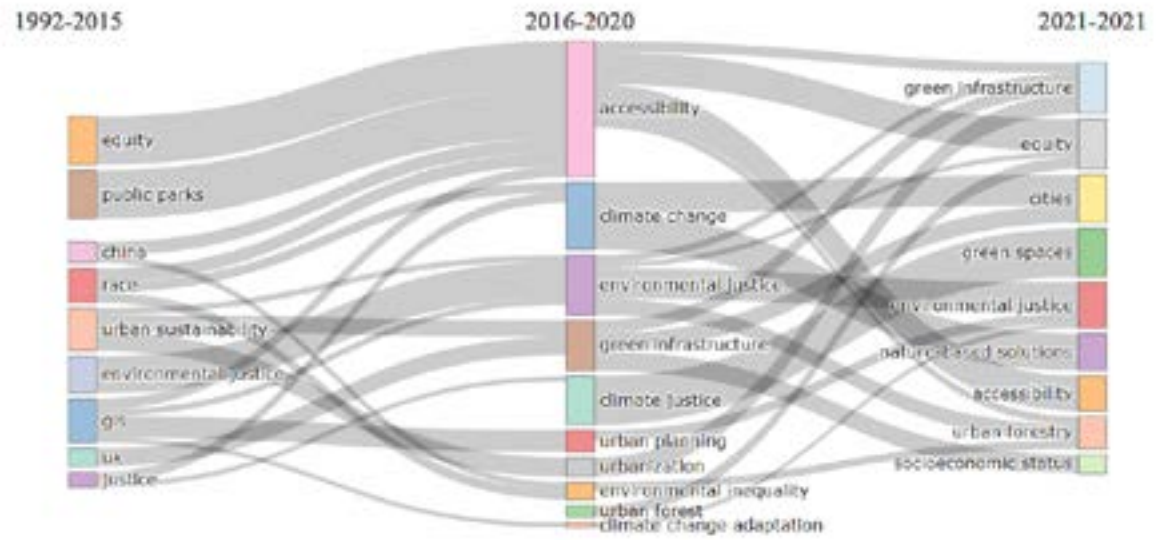
Still through keywords it is possible to notice which were the research directions, as Picture 2 shows. In this representation, the quantity of occurrences is viewed with the most frequent semantical associations over the period. This connection is represented by grey lines, which thickness is proportional to the quantity of occurrences.

The semantical evolution from 1992 to 2015 and from 2016 to 2020/2021 highlights that first the researches relate "*equity*" to "*environmental justice*", "*public pars*", "*race*", "*urban sustainability*" and "GIS" (*Geographic Information System*). After 2015, with an increase of the volume of scientific productions, there were also some additions to the diversity of themes, as "*accessibility*", "*climate change*", "*green infrastructure*", "*urban forest*" and "*urban planning*".

An aspect worthy of highlight is that the articles published in 2021 correspond to almost 20% of the total, what shows a very important growth in interest from the central theme and its associated terms. About these, the permanence of previous terms that have already been used and the appearance of new keywords more centered in green equity are noticed. They are: "*cities*", "green spaces" and "*socioeconomic status*".

The great increase verified in 2021, the last of the period studied in this research, is probably connected to the fact that the United Nations, through the *Food and Agriculture Organization of the United Nations*, declared the period of 2021 to 2030 the Decade on Ecosystem Restoration, with a broad focus that covers urban ecosystems.

Picture 2 - Semantical evolution Font



Source: authors

Main Periodics

The importance of evaluation of production in scientific magazines lays on the fact that in these the results of research are more readily disclosed and consumed, if compared to other ways of scientific knowledge publishing (DARKO, 2019). Thus, they are also more looked for by readers as information source and by authors as work publishing vehicle.

For the analysis of the text corpus selected, we point on table 2 the 10 main periodics, classified by number of publications. We can notice that the periodic *Landscape and Urban Planning* presents the greater number of publications and also the higher H-Index. H-Index operates with two metrics, productivity and quote impact of academic publications (ARIA; CUCCURULLO, 2017).

It was also possible to determine that the 10 periodics with greater number of publications are the same 10 with higher H-Index reported, only altering the classification.

Table 2 - Most influent periodics

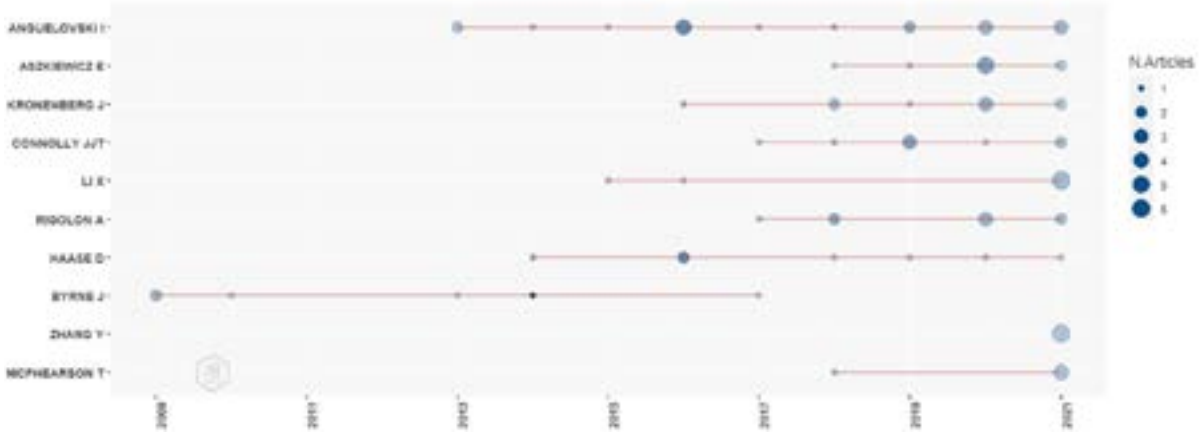
	Periodics	Articles	H-Index
1st	Landscape and Urban Planning	43	26
2nd	Urban Forestry and Urban Greening	34	17
3rd	Sustainability	27	8
4th	Local Environment	24	11
5th	International Journal of Environmental Research and Public Health	23	9
6th	Environmental Justice	21	6
7th	Cities	12	9
8th	Applied Geography	11	9
9th	Environmental Science and Policy	11	6
10th	Ecological Indicators	10	6

Source: authors

Main Authors

With respect to the classification of the 10 authors with more published articles (Picture 3), we observed that the production is centered near the last years of the research, with 89% of the articles, from a total of 84, published after 2015. From the authors, Anguelovski stands out with 18 articles published regularly since 2013 and as second most quoted author. And Byrne, even without recent publications, is the author that presents the higher number of quotes. We also highlight that, as showed in Picture 3, only in 2021, the year with most of the publications, authors like Li X, Zhang Y and McPhearson T published 6 and 4 articles, respectively. McPhearson's works approach themes like green infrastructure, ecosystemic services and access to parks in New York City, while Li X and Zhang Y treat mainly of equity in availability of green spaces and ecosystemic services associated to socio-economic and geographic factors, in addition to the perception and accessibility on green spaces and parks.

Picture 3 - Production of the main authors distributed over time



Source: authors

Scientific production of the countries and global collaboration network

With the data obtained, we identified the main productions by countries and the collaboration network existing. The list of countries and scientific production is on table 3. On the number of articles, the higher production is from the USA, followed by China, Germany, Spain, United Kingdom and Australia. We noticed that the greater amount of cooperation between countries is also concentrated among these first six countries.

Table 3 - Published articles and cooperation between countries

Classification	Countries	Published Articles	Cooperation
1	USA	486	82
2	China	157	24
3	Germany	71	38
4	Spain	63	28
5	United Kingdom	61	31
6	Australia	51	16
7	Canada	33	3
8	Netherlands	22	14

9	Poland	22	12
10	South Africa	18	8
11	Sweden	17	9
12	Brazil	16	5
13	Portugal	14	7
14	Belgium	12	9
15	Hungary	11	4
16	Norway	10	4
17	Italy	10	2
18	France	8	1
19	Korea	8	1
20	New Zealand	8	1
21	Colombia	7	2
22	Chile	6	1
23	Czech Republic	5	3
24	Estonia	4	1
25	Switzerland	4	1
26	Japan	2	2
27	Romania	2	1
28	Greece	1	2
29	Latvia	1	1

Source: authors

On Picture 4 it is possible to notice how these collaborations happen for two or more connections between countries. With the map it is possible to signal which were the main cooperation fluxes through the lines, where the thickness is related to the number of connections between the countries. The map also identifies in dark blue the country with the greater number of publications, USA, and fades the color saturation as the publications decrease.

On the map in Picture 4 we also notice that for the two countries with the higher number of publications, the existing fluxes are significant and diversified. In the case of the USA we verify that the cooperations happen in a larger quantity with Anglophone countries (mostly of English speakers), but still in a modest way with countries in the same continent, mainly the ones in South and Central America. And the fluxes with China happen in a more diversified way, where the most consistent relations are verified with the USA, countries in Europe and East Asia. Thus, we notice how Chinese researches are relevant not only in quantity but also in global connections when related to the academic study in green equity.

Picture 4 - Map of the collaboration network between countries with two or more cooperations

Source: authors

Final considerations

In this work we observed the specialties in green equity and its evolution in the studied literature, where it was possible to explore important aspects in the scientific approach and consolidate the study in a broad way, thus offering a panoramic view of the development of the theme in scientific research and its unfoldings until the current scenario.

It was possible to show how the research in green equity evolved since 1992. Initially associated to aspects of environmental justice, racial distinction, public parks and sustainability; green equity, mainly after the launching of the Sustainable Development Goals, by the United Nations in 2015, acquired more coverage and diversification in the studies, also associating to climate changes, accessibility to green spaces, ecosystemic services, green infrastructure and socio-economic issues.

Such questions, along with the increase of the publications, signal the importance of urban green equity in several axes of research and shows how such approaches converge with questions related to the quality of life, with connotations and unfoldings to interdisciplinary fields in Exact and Land, Human, Social and Health Sciences. Given the presented evidences, we understand that the researches will continue to grow and diversify over time, as the issues of equitative distribution and environmental justice gain global relevance and urgency, mainly in urban areas.

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