PUBLIC PERCEPTION OF BIODIVERSITY: A LITERATURE REVIEW OF ITS ROLE IN URBAN GREEN SPACES

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Received: 2nd July 2020, **Accepted:** 18th March 2021

ABSTRACT

The significance of biodiversity in the survival of human beings and enhancing the urban quality of life is evident from the empirical measurements and qualitative studies carried out across the globe. Despite its importance and value, burgeoning population and growing urbanization are posing a serious threat to biodiversity leading to biodiversity homogenization and ecosystem fragmentation. Moreover, studies reveal that management practices of biodiversity hardly take into account perception, needs, and knowledge of urban residents regarding biodiversity. Urban green spaces have a major role to play in the conservation of urban biodiversity. However, the triangular relationship between biodiversity, urban green spaces, and public perception is still unexplored.

With this aim, the paper attempts to compile, analyze, and synthesize the empirical findings to understand the state-of-the-art knowledge regarding public perception of biodiversity in urban green spaces. The search strategy acquired for the selection of papers resulted in 43 papers from 22 different countries of the world. The paper focuses upon an inclusive definition of urban green spaces, thus encompasses a wide variety of urban and peri-urban green spaces, parks, gardens, and waterfront urban spaces. The analysis of literature pattern reveals a recent increase in studies related to biodiversity perception over the last 10 years. It indicates a strong geographic bias in publications as well. Studies of animals including birds, insects, and reptiles are found scarce compared to plant species. The study could identify potential variables affecting human biodiversity perception which include species literacy, visitation rate, preferences, recreational, health, and restorative benefits, vegetation characteristics, nature connectedness, and conservation support. The paper also proposes a framework for understanding biodiversity perception in urban green spaces that can assist in improving our understanding of the relationship between human interactions and natural environments and framing strategies for urban development, landscape planning, and community health promotions.

Keywords: Urban biodiversity; perceptual dimension; species richness; nature connectedness; landscape planning; management policies.

INTRODUCTION

An increase in urbanized population is extensively impacting the sustainability of urban systems by affecting their ecological and biophysical components. As a result, the urban

population is getting greatly detached from natural environments. Thus, there arises a great demand for urban green space services as these spaces act as essential contributors to human health and quality of life (Maas *et. al*., 2006; Lee & Maheswaran, 2011). They have the capacity to enhance resilience and mitigate vulnerability to urbanization (Paul & Hirani, 2017). Kaplan & Kaplan (1989) have submitted decades back that exposure to nature is directly related to improved physical (White *et. al*., 2016), mental (Park *et. al*., 2010), and psychological health (White *et. al*., 2017) of the public. Owing to this, the human connection with nature in urbanized areas is of utmost importance, as, by 2050, about 70 % of the world population is supposed to be living in urban areas (United Nations, 2018), where health challenges are numerous (Dye, 2008).

Moreover, various studies have revealed that people prefer environments with natural elements as compared to built environments (Kaplan & Kaplan, 1989). This might lead to the supposition that humans positively perceive and prefer environments that are predominantly natural and rich in a diversity of life forms (Williams & Cary, 2002) i.e., a biodiverse environment.

Urban Biodiversity

Pickettetal (2016) expresses urban biodiversity as biophysical patterns occurring in the cities. It can also be regarded as an inextricable amalgamation of humans and non-human parts of urban ecosystems. For decades, ecological studies have urged that urbanized environments should be regarded as biodiversity refuges. Hence conservation concerns should be broadened from pristine to urban green areas (Muratet *et. al*., 2008). But the accelerating pace of urbanization is compelling the cities to be built in the areas of high biodiversity which is alarming the persistence of ecological communities and various species globally (Parrisa *et. al*., 2018). Biodiversity is under threat due to these challenging conservation issues and hence we need to ensure that the growth of the cities occurs in a biodiversity-friendly way (Miller & Hobbs, 2002; Marzluff, 2002; Seto *et. al*., 2012; Dearborn & Kark, 2010; Shwartz, *et. al*., 2014b).

In order to conserve biodiversity in urban areas effectively, knowledge from a broad set of disciplines is required (Ahern, 2013). With cooperation from multiple disciplines, urban biodiversity can play a major role in attaining urban sustainability (Jalkanen *et. al*., 2020). Since, built environment professionals like architects, landscape architects, urban planners, and urban designers directly influence the evolution of the form and fabric of urban environments, they can act as key persons in the endurance and protection of urban biodiversity (Parrisa *et. al*., 2018).

Urban Green Spaces and Public Perception

Green spaces have acquired utmost importance in urbanized environments, as they serve as hosts for biodiversity (Cornelis & Hermy, 2004; Nielsen, *et. al*., 2013). Apart from aesthetic benefits (Chen *et. al*., 2009; James *et. al*., 2009), urban green spaces add to health (Southon *et. al*., 2018) and recreational benefits, assist in enriching urban cohesion (Germann-Chiari & Seeland, 2004; Tzoulas *et. al*., 2007; Ka´zmierczak, 2013), and promote human wellbeing (Arnberger, 2012; Mitchell & Popham, 2008). Recognition of the synergies amongst these ecological, social, and restorative functions of green space services can assist in better planning of these spaces (Young *et. al*., 2020).

It becomes imperative to study the impact of urban green spaces on humans as these spaces provide large scope for studying the human perception of their physical environment particularly, biodiversity. Yet analysis of the human perception of green space and biodiversity within is challenging and thus not much explored (Kothencz & Blaschke, 2017).

This is because of the subjective nature of human perception of the ambient environment where properties of and benefits derived from these spaces differ from person to person (Langemeyer *et. al*., 2015; Hernández-Morcillo *et. al*., 2013) and are thus interpreted individually. Moreover, landscape perception is an active process that occurs amid the organisms and their environment (Kaplan & Kaplan, 1989). Characteristics of a place are greatly influenced and shaped by one's individual perceptions (Tyrväinen *et. al*., 2007). Greater insight into people's perception of green spaces can assist in better design and management of these spaces and also add to their attractiveness. This might result in greater enjoyment and usage of such spaces and lead people to engage themselves in its conservation initiatives (Shwartz *et. al*., 2014a). It demands in-depth knowledge of the complex relationship that exists between human well-being, their aesthetic experience, and perceived biodiversity (Hoyle *et. al*., 2017b). Hence both quantitative, as well as qualitative assessment of public perception of urban green space services, especially biodiversity, is essential for assessment of the urban quality of life.

Unfortunately, urban biodiversity conservation efforts hardly take into account the perceptions, needs, and knowledge of the public. Understanding of lay people's perception of urban green spaces and biodiversity is limited which might add to a crucial knowledge gap in understanding public perceptions and preferences for such spaces. To bridge this gap, interdisciplinary based research is needed urgently.

Public Perception of Biodiversity

According to Balmford *et. al*. (2002), people care about the things they know. Bornstein and D'Agostino (1992) and Zajonc (1968) have explained this through the concept of 'mere exposure effect' where familiarity with mere exposure is correlated with positive effects on attitudes and preferences. Based on this, exposure to and knowledge of the people about species can be considered as a good starting point in order to involve the people in biodiversity. But biodiversity is an abstract and challenging concept to convey to the public as it can be interpreted in different ways. (Van & Wals, 2002).

According to Convention on Biological Diversity (CBD, 1992), biodiversity can be defined as "the variability among living organisms from all sources that include, terrestrial, marine and other aquatic ecosystems along with their ecological complexes incorporating diversity within species, between species, and of ecosystems". Apart from this scientific dimension, it also has social, ethical, and economical dimensions (Gayford, 2000; Wals & Weelie, 1997). This multi-dimensional character of biodiversity makes it difficult for the general public to grasp, comprehend, and recognize it (Fischer & Young, 2007; Turner-Erfort, 1997; Lindemann-Matthies & Bose, 2008).

Though the importance of biodiversity is clear, its role is still unclear i.e., how accurately people perceive it and what are the factors that influence this accuracy is poorly understood (Southon *et. al*., 2018). This can be investigated through the concept of species literacy amongst the people (Hooykaas *et. al*., 2019) which is based upon skills of identifying and appreciating the species amongst the people. Various researchers have pointed out that the necessary skills required for identifying and appreciating plants are often lacking particularly amongst the urban public (Clergeau *et. al*., 2001). In addition to the above, inquiring how experts and the general public conceptualize biodiversity can also help in better planning of green spaces and enhancing the role of city residents in the process of planning (Morgan *et. al*., 2002; Shwartz *et. al*., 2014a).

Urban green spaces serve as significant recreational resources as well as important habitat for the conservation of flora and fauna in an urban landscape (Zhou & Chu, 2012) and usually

found to possess a higher level of biodiversity as compared to the surrounding urban matrix (Matteson *et. al*., 2013; Strohbach *et. al*., 2013).

Most of the research works (e.g., Qiu *et. al*., 2013) have hypothesized that urban green space users perceive and appreciate biodiversity values while using it for recreation and found that those values are positively related to the preferences. But the knowledge regarding the degree to which the dual purpose of recreation and conservation can be achieved in the same spaces is still not evident. It is also not clear whether the presence of recreational facilities provided in the green spaces conflicts with high biodiversity, i.e., the trade-off between the space available for public amenities and that for natural features. Hence it is imperative to understand the compatibility between recreation and biodiversity and study the correlation between these two components in order to appreciate the benefits derived from such spaces (Wood *et. al*., 2005; Qiu, 2014).

Qiu *et. al*. (2013) have pointed out that not much attention has been given to the effect of biodiversity on public preference. One aspect related to this issue is to contemplate whether higher biodiversity, specifically higher vegetation cover attracts or discourages people from visiting the green space. If people prefer to visit the public parks with a lower level of vegetation cover, the benefits derived from this interaction with nature could be constrained to a greater extent.

Apart from this, socio-demographic factors might affect the public perception of biodiversity. These include age, gender, economic status, education level, ethnicity, etc. which might influence the visitation frequency and preference to different types of parks (Jim & Shan, 2013; Ho *et. al*., 2005; Zanon *et. al*., 2013; Lin *et. al*., 2014; Wende *et. al*., 2012). For instance, older people might have acquired more knowledge about the biodiverse environment due to more exposure to or more interest in biodiversity (Southon *et. al*., 2018). Thus, the role of vegetation cover in attracting people from various socio-demographic backgrounds to public parks needs to be studied (Shanahan *et. al.*, 2014).

Though present epidemiological methods testing the interrelation between green spaces and psychological well-being consider all vegetation covers as equal, there might be a possibility that variation in ecological quality might affect the association between green spaces and the health and well-being of the visitors (Wood *et. al*., 2018). According to Van Den Berg *et. al*. (2014), experimental laboratory work has proposed that not much relation exists between restorative benefits and different types of natural scenes. Hence it is of utmost importance that the landscape architecture designing actual plant communities should have a better understanding of how people perceive the form, character, and composition of planting shrubs, trees, and plants as most of the research work concerning the human perception of green spaces have focused on designed planting in a much generic sense (Hoyle, 2015).

There is also a lack of evidence about how people with different socio-demographic characteristics experience green space characteristics like vegetation type, its structure, density, and aesthetics predominantly at deliberately designed and managed green spaces (Hoyle, 2019). Moreover, identifying the characteristics of vegetation that are conducive to restoration can assist in designing green spaces that can fetch health and conservation benefits (Young *et. al*., 2020).

On one hand, biodiversity loss is accelerating day by day due to population growth, unplanned development, and climate change whereas on the other hand, we have begun to appreciate the human health benefits that are realized from experiencing nature and biodiversity (Sandifer *et. al*., 2015). Looking at the growing evidence that human well-being is enhanced by exposure to nature, it becomes vital to understand the relationship between

human health and exposure to biodiverse environments as specific qualities of green spaces offering health benefits still remain poorly understood (Dallimer *et. al*., 2012).

Thus, little is known about various qualities of green spaces that offer benefits to human well-being (Fuller *et. al*., 2007) particularly with respect to psychological and mental health. One such green space quality that is found to affect human health (psychological and mental) is nature connectedness or one's subjective connection with nature. It is also used as an environmental measure for predicting sustainable attitudes and behaviors (Zelenski & Nisbet, 2014). The benefits of nature connectedness are rooted in the concept of Biophilia (Wilson, 1984), which focuses on the fundamental intrinsic bond between human beings and nature and based on the postulation that humans have an inherent inclination and affinity with Nature (Grinde & Patil, 2009). Consequently, it becomes one of the influential aspects of human experience (Kellert, 1997). Thus, measuring one's affective sense of connectedness to nature is also important for understanding the complex relationship between humans and the natural world (Mayer *et. al*., 2004).

Aim of the Review

The review aims at compiling, analyzing, and synthesizing empirical findings regarding public perceptions of biodiversity, particularly in urban green spaces. Based on the above studies, the review focuses on addressing, assessing, and drawing broader conclusions about the following questions through scholarly knowledge:

1) To what extent general people acquire knowledge about species diversity/richness (biodiversity)?
2) Whether the presence of recreational facilities conflicts with high biodiversity?
3) Does people's support for biodiversity conservation differ within the population sub-groups?
4) Do socio-demographic factors influence public preference for biodiversity and visitation frequency to green spaces?
5) Do the various types and characteristics of vegetation like its structure, density, aesthetics, etc. affect biodiversity perception and restoration amongst people?
6) Does a correlation exist amongst perception of biodiversity, human health, and people's nature connectedness/relatedness?

METHOD

The review focuses on empirical data discussing the public perceptions of biodiversity in urban green spaces as well as other spaces visited by them, like, peri-urban protected areas, forested areas, and wetlands thus encompassing an inclusive definition of urban green spaces with an aim of understanding the perception differences amongst these spaces. All these spaces include urban parks, urban gardens, urban meadows, community gardens, urban squares, and streets, peri-urban natural protected areas, forest plantations, woodlands, urban riparian green spaces, wetlands, etc. Papers that reported data regarding urban biodiversity but omitted data about the perception of biodiversity were beyond the scope of this review.

Search Strategy

The literature search was conducted from February 2020 to April 2020. The search was confined to papers published in the major scientific databases, Scopus and Web of Science between 2000 till 2020. The search strategy incorporated either one or a combination of some of the keywords from search terms like 'urban biodiversity, 'public perceptions', 'perception of biodiversity, 'urban green spaces, or 'urban open spaces.' The keywords were searched

within the title, abstract, and keywords of the publication, and the search was restricted to peer-reviewed international journal publications that were written in English only. It was realized that though data related to urban biodiversity was enormous, papers relating to perception studies of urban biodiversity were comparatively much lesser. So, the scope was widened beyond the protocol by using snowballing technique thus including the articles that were found relevant while searching for some other empirical data and also those found in the references of the papers obtained from the searches that were focusing on public perceptions of biodiversity and fulfilled the inclusion criteria.

Results of Search Strategy

Journal wise publications

The search related to perception studies of urban biodiversity generated a total of 42 hits from Scopus and 47 hits from Web of Science. After screening, the articles based on the above search strategy and snowballing technique, 43 potentially eligible papers were retrieved which included 40 research papers, one review paper, and two masters' theses. It was found that the journal publishing the highest number of research papers was Landscape and Urban Planning followed by Urban Forestry & Urban Greening. In all about 21 journals published the papers revealing that a range of journals shared interest in this topic (Two pieces of research being master's theses are omitted from the count) (Table 1).

Table 1: Journals publishing most research papers on public perceptions of urban biodiversity

Journals containing two or more papers	Number of papers	Percent of papers*
Landscape and Urban Planning	14	31 %
Urban Forestry & Urban Greening	3	7 %
Land Use Policy	2	4 %
Environment and behaviour	2	4 %
Biological Conservation	2	4 %
Ecosystem Services	2	4 %
Journal of Environmental Psychology	2	4 %

*Percentage does not add up to 100 % as only journals with 2 or more papers are shown.

Bibliographic Overview of Studies

Empirical data has been collected through 43 research works on urban green spaces situated in about 22 countries. Prominent geographic unevenness in coverage is evident from Fig. 1 where Europe is showing a large number of studies whereas not many papers were found from African countries and several countries of the Global South. This has also been established by the research work done by Hoyle *et. al*. (2019). Thus, there exists a knowledge gap in terms of perception studies of urban green spaces in Africa and countries of the Global South. On the contrary, Europe being at the top in perception studies, it could be derived that maximum awareness regarding biodiversity and its perception is amongst the European countries. Interestingly, it was revealed that maximum research work has been carried out in the UK with 14 papers contributing to almost half of the research work done in Europe (Fig. 2) and 33 % of entire papers identified on perceptions of biodiversity from 2000 to 2020.

Fig. 1: Continent wise Number of Papers Published

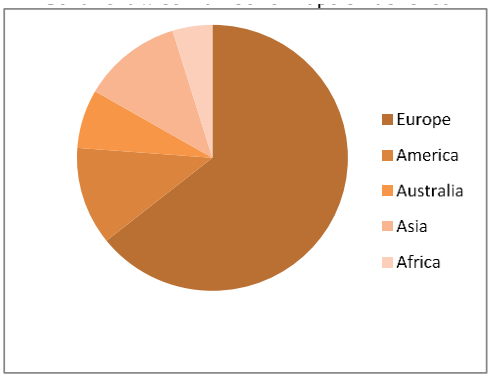
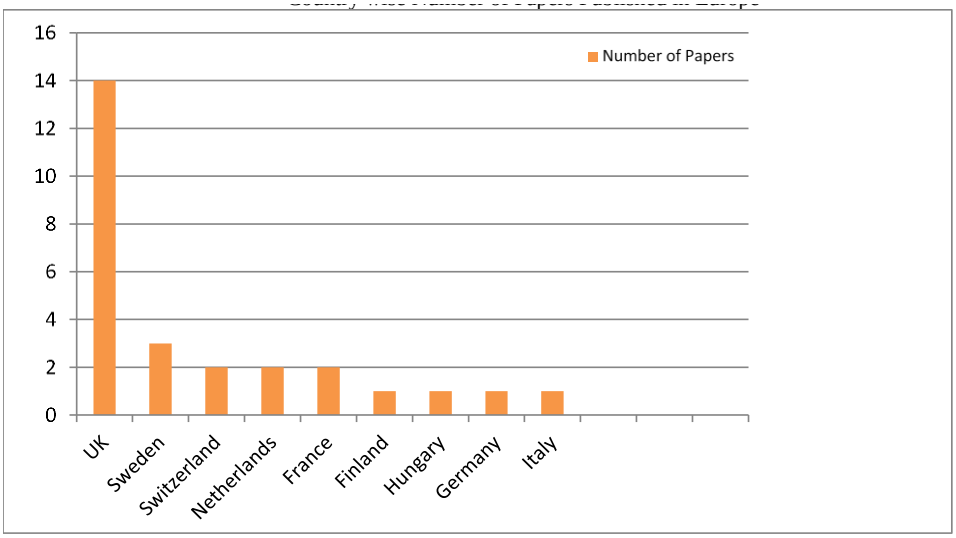
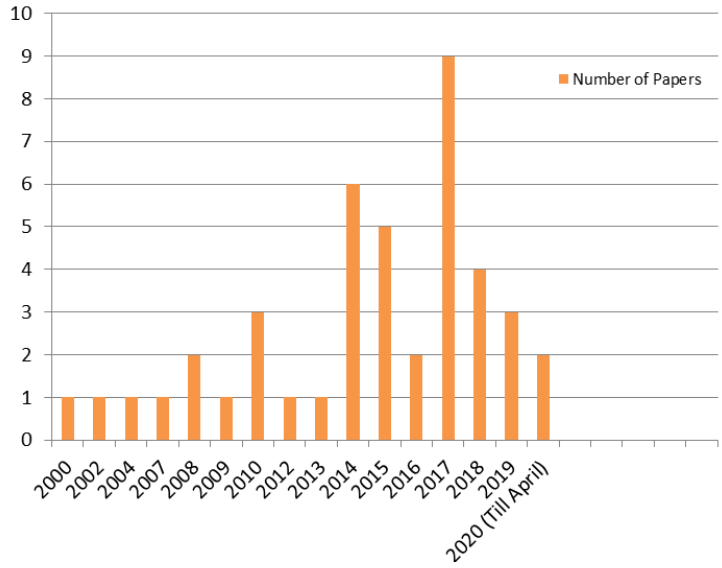


Fig. 2: Country wise Number of Papers Published in Europe



It was also discovered that about 84 % of research work (n = 36) has been published from 2010 to 2020 (Fig. 3). This directs towards the fact that the interest in studying urban green spaces and biodiversity perception has gained momentum recently during the last decade only. Recent awareness regarding biodiversity could be related to the enduring global urbanization, growth of urban ecology, and increase in recognition of the significance of biodiversity to human health and wellbeing (Rupprecht *et.al*., 2015).

Fig. 3: Number of Papers Published from 2000 to 2020



Data Extraction and Synthesis

Publication patterns have been systematically analyzed and the main findings of all 43 research works along with their implications are discussed after analyzing trends and patterns in literature obtained from Table 2. Results are represented through figures and tabulations to present and synthesize findings from all 43 articles efficiently following similar kinds of presentation and analysis methods used in recent literature reviews (e.g., Rupprecht *et. al.*, 2015). Instead of using quantitative synthesis and meta-analysis in order to determine the overall trends, qualitative synthesis and assessment were deemed appropriate looking at the heterogeneity of the data in terms of the geographical region of study, spaces studied, study methodology, data collection methods, and key findings as applied in other review studies carried out on urban biodiversity (e.g., Nielsen *et. al.*, 2013).

Table 2: Data extracted from the studies showing year of publication, name of author(s), country, types and number of spaces studied, sample size/type, variables studied, and method of data collection used.

Year	Author	Country	Types of Spaces Studied	No. of Spaces Studied	Species Studied	Sample Size/Type	Variables studied	Data Collection method
2020	Young et.al.	Switzerland	domestic and allotment gardens	301	Plants	300 leisure gardeners	Restorative benefits	Questionnaire survey
2020	Jalkanen et.al.	Finland	Municipal Cities	4	Plants, birds, animals (mammals), butterflies, beetles	24 Taxonomic Experts	Vegetation characteristics (Spatial prioritization)	Biotope-mapping and expert opinions.
2019	Hoyle et.al.	UK	Woodland, shrub and herbaceous planting	31	Plants and animals (invertebrates)	1411 (survey questionnaire) and 34 (in depth interviews)	Vegetation characteristics, Nature connectedness	Questionnaire survey
2019	Hooykaas et.al.	Netherlands	_	_	Birds, animals (mammals, amphibian and invertebrates)	4750 (3210 lay people, 602 school children and 938 biodiversity professionals)	Experts and public conceptualization of biodiversity	Questionnaire survey, species identification test.
2019	Hassan et.al.	Malaysia	Wetland	1	_	403	Conservation support	face-to-face interviews with urban and rural households
2018	Campbell-Arvai	Canada	Municipal City	_	_	18 subject matter experts and 28 citizens	Experts and public conceptualization of biodiversity	Semi-structured interviews
2018	Wood et.al.	UK	Urban parks	12	Plants, birds, butterflies	128	Restorative benefits, Socio-demographic factors	Questionnaire survey
2018	Southon et.al.	UK	Experimental perennial urban meadows	5	Plants	240	Human health (physical and mental) Nature connectedness	Questionnaire survey
2018	Coldwell and Evans	UK	Municipal Cities	6	_	200 respondents	Human health (Mental)	Door-to-door surveys
2017	Paul and Nagendra	India	City parks	4	Plants and animals	123	Visitation rate	Interview, onsite observation
2017	Kothencz and Blaschke	Hungary	Urban parks	5	Plants	125(Field survey), 130 (Internet survey)	Vegetation characteristics	Questionnaire survey, GIS
2017	Hoyle et.al.	UK	Woodland, shrub and herbaceous planting	31	Plants	1411 (survey questionnaire) and 34 (in depth interviews)	Vegetation characteristics Restorative benefits	Questionnaire survey and in-depth interviews

Year	Author	Country	Types of Spaces Studied	No. of Spaces Studied	Species Studied	Sample Size/Type	Variables studied	Data Collection method
2017	Hoyle et.al.	UK	Woodland, shrub and herbaceous planting	31	Plants	1411 (survey questionnaire) and 34 (in depth interviews)	Vegetation characteristics	Questionnaire survey and in-depth interviews
2017	Southon et.al.	UK	Perennial meadow creation (experimental sites and control sites)	10	Plants	420	Preferences (meadows)	Photo elicitation with questionnaire survey
2017	Coldwell and Evans	UK	Small and large urban areas in pairs	6	_	286	Species literacy, Visitation rate, Conservation support	Interview (scales of pro-environmental behavior), photo elicitation
2017	McGinlay et.al.	UK	County	1	Birds, plants (flowering), butterflies	549 members	Preferences (charismatic species)	Questionnaire survey
2017	Hoyle et.al.	UK	Experimental perennial meadows	7	Plants	8 stakeholder managers	Preference (meadows)	Semi-structured interviews with local authority managers
2017	Palliwoda et.al.	Germany	Recreational parks	2	Plants	15 park users	Vegetation characteristics	Observation, interviews
2016	Illiassou et.al.	Niger (West Africa)	Cities	2	Plants and animals	800 residents	Conservation support, Preferences	Ethno biological survey, questionnaire survey
2016	Van den Berg et.al.	Netherlands	Unspectacular natural and built spaces	40	Plants	40 students and university employees	Restorative benefits	Photo elicitation
2015	Muratet et.al.	France	Urban park	1	Plants	1 botanist and 100 park users	Vegetation characteristics	Semi-structured interview
2015	Hoyle	UK	Shrubs, woodland, herbaceous planting	31	Plants	1410 Questionnaire survey, 34 in depth interview	Vegetation characteristics	Questionnaire survey and indepth interview
2015	Sandifer et.al.	—	—	_	_	—	Human health	Literature review
2015	Carrus et.al.	Italy	Urban square with green elements, urban parks, forest plantation, peri-urban natural protected areas	4	Plants	569 residents	Restorative benefits	Questionnaire survey

Year	Author	Country	Types of Spaces Studied	No. of Spaces Studied	Species Studied	Sample Size/Type	Variables studied	Data Collection method
2015	Shanahan et.al.	Australia	Urban parks	324	Plants	670	Visitation rate, Nature connectedness	Questionnaire survey, (nature relatedness scale)
2014	Bakhtiari et.al.	Sweden	__	_	_	51 participants (local citizens)	Species literacy, Conservation Support	individual interviews and group discussions, thinking aloud, picture drawing
2014	Koklukaya et.al.	Turkey	Natural park	1	_	20 prospective science teachers	Biodiversity knowledge	Questionnaire survey
2014	Qiu	Sweden	Transect from the centre of the city to its outskirts, urban green spaces, park	8	Plants	121 respondents	Vegetation characteristics, Recreational benefits,	Biotope mapping, questionnaire survey, Visitor employed photography
2014	Shwartz et.al.	France	Small public gardens	14	Flowering plants, birds, butterflies, insects	1116 garden users	Vegetation characteristics	Semi-structured interview
2014	Van den Berg et.al.	UK	urban street, parkland, tended woodland, wild woods	4	Plants	102 participants	Vegetation characteristics, Restorative benefits	Video elicitation
2014	Zelenski and Nisbet	Canada	_	_	_	331 students and 619 community people	Nature connectedness	Questionnaire Survey
2013	Qiu et.al.	Sweden	Recreational park	1	Plants	69 park visitors	Species literacy, Vegetation characteristics, Recreational benefits	Visitor-employed photography (VEP)
2012	Dallimer et.al.	UK	Riparian green spaces	34	Plants, butterflies, birds	1108 green space visitors	Human Health (psychological)	Questionnaire Survey

2010	Vodouhê et.al.	Benin	National Park	1	_	164 residents	Conservation support	Interview, questionnaire survey
2010	Leslie et.al.	Australia	Municipal City	1	Plants	94 residents	Vegetation characteristics	Mail survey, GIS
2010	Hur et.al.	Ohio	Municipal City	1	Plants	725 residents	Vegetation characteristics	Questionnaire survey, GIS
2009	Chen et.al.	China	Flower Garden	1	Plants	178 garden visitors	Vegetation characteristics, Recreational benefits	Questionnaire survey and photo-based evaluation
2008	Matthies & Bose	Switzerland	Park, botanical garden, natural history museum	3	Plants	161 school pupils, 110 non-graduates and 96 graduates	Species literacy, Socio-demographic factors	In depth interview and questionnaire survey
2008	Chang et.al.	Taiwan	naturalness/ wilderness scenes	_	Plants	110 laboratory participants	Restorative benefits	Photo elicitation
2007	Fuller et.al.	UK	Green spaces	15	Plants, Birds, Butterflies	312 green-space users	Human health (Psychological)	Semi-structured interviews
2004	Mayer et.al.	Ohio	__	_	_	343 (public place visitors, Psychology students, Undergraduate psychology majors)	Nature connectedness	Questionnaire survey
2002	Williams and Cary	Australia	Woodland and forest	3	Plants	1000 urban and rural resident	Preference, Conservation support	Photo elicitation
2000	Armstrong	United States of America	Community Gardens	63	Plants	20 community garden program coordinators	Human health	Telephone interview

RESULT

In all about 1009 urban spaces were studied in the papers with 17 types of urban spaces including urban parks and gardens, urban squares with green elements, wetlands and riparian public green spaces, peri-urban natural protected areas, and woodlands, etc. thus encompassing an extensive category of urban spaces. Out of the total 43 research works, 23 (54 %) were focusing exclusively on plant species whereas only 1 (2 %) on animal species. Nine works (21 %) were found to be studying both plants and animal species while the remaining 10 works (23 %) were concerning about the general biodiversity knowledge and conceptualization amongst the public, their support to conservation, and nature connectedness. This pointed out the fact that compared to plant species (n = 32.75 %), perception studies regarding animal species (n = 10.23 %) were very low which led to a very important knowledge gap. Moreover, out of the total animal species studied (n = 10), interest in studying birds, butterflies, and beetle species was found to be greater which was evident from 7 papers (16 %) that discussed bird species and 6 papers (14 %) that discussed butterfly/insect/beetle species. Also, places like urban parks, gardens, meadows, and herbaceous plantings, were found to be most popular and extensively studied (n = 25.58 %) while, riparian public green spaces were least studied (n = 2.5 %).

A wide variety of methods (about 15 types) was implemented for collecting the perception data including observations, surveys, interviews, photo, and video elicitation, visitor employed photography (VEP), group discussions, picture drawings, mapping, Geographical Information System, species identification tests, etc. However, the study revealed that most of the researchers still relied on traditional methods of data collection for studying perceptions like questionnaire survey (n = 22) which was used by almost half of the researchers (51 %), and interviews (n = 9) used in 21 % of the papers.

Biodiversity Knowledge

Answer to the first research question could be obtained through two types of papers, those studying general species literacy amongst the public and those exploring the concept of public perception of biodiversity in comparison to the experts.

Species Literacy amongst the Public

Four papers (9 %) were found to be discussing species literacy amongst the general public. Results unfolded that higher species literacy is positively associated with higher visitation frequency and it could be enhanced through less intensely urbanized cities having better access to the countryside (Coldwell & Evans, 2017). While enquiring about the laypeople's understanding of forest ecosystem attributes, Bakhtiari *et.al.* (2014) realized that people had an instinctive understanding of the ecological concept like biodiversity and values associated with it. Moreover, research carried out by Qiu *et. al.* (2013) indicated that people can accurately perceive the differences in biodiversity and their knowledge about biodiversity could be positively related to preference to biodiversity. In contrast with this, Matthies & Bose (2008) realized that laypeople are unaware of the concept of biodiversity and could not recognize it to a wider extent.

Experts and Public Conceptualization of Biodiversity

Two research works (5 %) focused on detecting the differences in the understanding of the term 'biodiversity' between the general public and biodiversity professionals and experts. Research indicated that the literacy rate about native species was low amongst laypeople compared to professionals and increased with the age and level of education and found to be associated with a positive attitude towards nature (Hooykaas *et. al.*, 2019). Another research

revealed that while citizens were knowledgeable about biodiversity, there existed a gap in understanding about some of the drivers of biodiversity loss compared to subject matter experts, i.e., edge effects, habitat isolation, or the destruction of biodiverse habitats (Campbell-Arvai, 2018).

Recreational Benefits and Biodiversity

Three papers (7 %) made an inquiry regarding the perceived recreational benefits of biodiversity. Results indicated that ecological knowledge could have a positive influence on preferences for biodiversity with respect to recreational benefits (Qiu *et. al*., 2013). Chen *et. al*. (2009) demonstrated that people have different expectations regarding the recreational benefits of urban green spaces in terms of their auditory, tactile, olfactory, and visual qualities. In interdisciplinary research, Qiu (2014) tried to link biodiversity with recreational benefits by studying trade-offs and synergies between biodiversity conservation and recreational values. The research revealed that people could perceive recreational values in urban green spaces through eight sensory dimensions that were associated with biotopes.

Support to Biodiversity Conservation

Six papers (14 %) were found to be discussing people's support for biodiversity conservation. While studying conservation support of urban and rural population subgroups to wetlands, Hassan *et. al*. (2019) realized that urban people favored wetland conservation and had a positive willingness to pay for its conservation whereas rural people were not much willing to pay for conservation. But both groups showed strong preferences for flood risk reduction. Coldwell & Evan (2017) asserted that regular visitors of green spaces had higher support for conservation and less urbanized cities could maximize public support for biodiversity conservation. People's perception of biodiversity conservation was also seen to be strongly related to perceived benefits derived from the park (Vodouhê *et. al*., 2010). Similarly, a positive association was found also to exist between landscape preferences and the protection of natural environments (William & Cary, 2002). According to Bakhtiari *et. al*. (2014), people's attitudes towards biodiversity might be rooted in their mental constructs that could assist in targeting conservation management practices.

Thus, public perception played an important role in urban space management and could positively contribute to environmental protection policies and decision making (Illiassou *et. al*., 2016).

Socio-Demographic Factors, Visitation Rate and Preferences to Biodiversity

Two papers (5 %) were found to be studying biodiversity perception of people from various social backgrounds, specifically in terms of their education. The study indicated that graduates were most knowledgeable about biodiversity, whereas non-graduates were least (Matthies & Bose, 2008). Furthermore, young people, as well as adults, held widely inaccurate ideas about plant species richness. Paper by Koklukaya *et. al*. (2014) attempted to determine the perception of the prospective science teachers which revealed that the teachers were not much aware regarding biodiversity. It pointed out the need for educating prospective teachers about biodiversity and urged to place biodiversity in the educational programs.

Three papers (7 %) were identified that were discussing visitation rate while 5 papers (12 %) discussed public preferences. A positive association was seen to exist between visitation rate and biodiversity knowledge (Coldwell & Evans, 2017). In another research, it was realized that the visitation rate was not reliant on the level of tree cover and remnant vegetation (Shanahan *et. al*., 2015). While analyzing the correlation between frequency of

use and distance to green spaces, Paul & Nagendra (2017) pointed out that the visitation rate was dependent upon socio-demographic factors. Compared to old -people, younger visitors traveled long distances to visit green spaces. Also, male visitors had a higher visitation rate in a week than women as women had to face higher constraints while visiting recreational spaces. The number of daily visitors was found to be decreasing with the increase in distance to the green space.

While studying public preferences for biodiversity, it was displayed that most people preferred plants to animals because of their benefits in the form of shade and fruits (Illiassou *et. al*., 2016). In one of the studies, Williams & Cary (2002) found that urban people preferred biodiversity in terms of passive and active recreation like walking whereas rural people valued it for its benefit to their stocks in the form of grass. While assessing general people's preferences for meadow style planting, Southon *et. al*. (2017) explored that people preferred and appreciated meadows compared to both, herbaceous borders and formal bedding planting as well as mown amenity grasslands. Hoyle *et. al*. (2017a) studied perennial meadow planting with respect to local authority managers' perceptions and discovered that perennial meadows were valued and perceived as a realistic alternative to amenity mown grass that could help in enhancing local biodiversity if implemented in consultation with the general public. It was also found that people prefer high charismatic species groups due to the greater levels of benefits they derive compared to less charismatic species groups (McGinlay *et. al*., 2017).

In addition to this, various papers were found to be discussing the influence of socio-demographic factors like age and gender on various aspects related to biodiversity such as species richness, restorative benefits, etc. which are discussed in the respective subheads.

Vegetation Characteristics and Restorative Benefits

Thirteen papers (30 %) were identified discussing perceptions regarding various characteristics of vegetation while 5 Papers (12 %) studied restorative benefits of biodiversity whereas two papers (5 %) were found to be discussing the relationship between restorative benefits and vegetation characteristics.

Out of the three papers that used GIS for measuring objective characteristics of green spaces, one paper by Kothencz & Blaschke (2017) revealed that no strong links existed between objective measures of the urban parks and related subjective evaluations of the parks by the public. Similarly, while using a normalized vegetation index (NDVI) derived from satellite imagery, Leslie *et. al*. (2010) discovered a lack of agreement between the perceived and objective measures of greenness. They attributed it to the fact that the perceived measure evaluated "ground-level" greenness that is seen from the participants' eyes, while NDVI assessed the amount of green surface seen from above only. The objective measure involved the quantitative aspect of green elements whereas the perceived measure might involve quality of greenness as well. Hur *et. al*. (2010) used GIS and Landsat satellite imagery and realized that perceived naturalness increased with an increase in perceived openness and as perceived naturalness increased, satisfaction with the presence of trees also increased.

Talking in terms of individual plant species, Hoyle *et. al*. (2017c) asserted that the majority of people were positive towards non-native species if those were better adapted to climate change. As observed by Palliwoda *et. al.* (2017), a considerable proportion of activities were seen to be performed related to individual plant species as compared to other park activities. It was also found that as compared to men, more women interacted with plant species. Muratet *et. al*. (2015) discovered that park users could recognize cultivated plants promoted by the gardeners while botanists mostly observed spontaneous species.

Regarding species richness, it was established that though people strongly preferred rich diversity of species for their well-being in the gardens, they often underestimated species richness and no significant correlation existed between observed and estimated species richness (Shwartz *et. al*., 2014). The estimation of plant species richness was also much lower in the case of park users than the botanists. Species character, planting structure, and flowering were determined to have a significant effect on perceptions of neatness, attractiveness whereas socio-demographic factors, beliefs, and values had a lesser influence on their reactions to the planting (Hoyle, 2015). Moreover, the naturalness of the space was perceived as biodiverse, attractive, and restorative, but not essentially tidy and was found to be related to an individual's educational qualification and gender (Hoyle *et. al*., 2019).

Regarding preference to various types of vegetation, Chen *et. al*. (2009) found that environmental aesthetic preference did not vary significantly with age and gender but scenic beauty could provide a relaxing environment for the users. People preferred half-open park compared to complex vegetation indicating negative relation between high biodiversity and preference as well (Qiu *et. al*., 2013). Besides, urban forests were frequently perceived as rich in species than open green spaces (Qiu, 2014). It was also realized that on-site preference to biodiversity was highly context-specific and was triggered by specific features rather than the overall scenery and character of the setting. Jalkanen *et. al*. (2020) revealed that spatial prioritization could assist in urban land-use and green infrastructure planning in order to maintain biodiversity.

While addressed the question regarding visual features that trigger restorative responses in people, Van den Berg *et. al*. (2016) concluded that natural scenes were mostly rated more restorative than built scenes. The positive effect of biodiversity was observed on perceived restorative properties and self-reported benefits derived from urban and peri-urban green spaces (Carrus *et. al*., 2015). Finding by Wood *et. al*. (2018) indicated that facilities on the site like cleanliness, amenities present, etc. related positively to restorative benefits but unrelated to age, gender, and ethnic background. A large degree of compatibility was found between psychological measures of restorativeness and physiological responses while viewing images of wildland scenes (Chang *et. al*., 2008). This was established through the improved scores on the perceived restorativeness scale that corresponded to increased EMG (Electromyography) and EEG (electroencephalogram) readings and lower BVP (Blood Volume Pulse) measurements. These findings proved to be significant to the psychophysiological values and benefits of the wildland–wilderness environments for human restoration. Allotment gardens were also found to be highly restorative amongst the gardeners as compared to domestic gardens. A positive association existed between restoration and the number of plant species whereas garden-related stress among a number of gardeners was found to be negatively related to the restoration (Young *et. al*., 2020).

While exploring the relationship between restorative benefits and vegetation characteristics, a weak correlation was found to exist between perceived attractiveness of the vegetation and restorative effects (Hoyle *et. al*., 2017b). Though there was a high aesthetic preference for colorful planting, green planting was also greatly valued whereas planting with natural structure was perceived as more restorative. Respondents also described wild woods to be more arousing than the parkland and tended woodland (Van den Berg *et. al*., 2014).

Biodiversity, Human Health, and Nature Connectedness/Relatedness

Four papers (9 %) were identified discussing nature connectedness and 5 papers (12 %) discussed human health with respect to biodiversity perception. One paper discussed the relationship between both nature connectedness and people's physical and mental health.

Hoyle *et. al*. (2019) found naturalness as biodiverse and was related to an individual's connectedness to nature. People with greater nature connectedness traveled even greater distances for more vegetated parks (Shanahan *et. al*., 2015). Mayer *et. al.* (2004) used the connectedness to nature scale (CNS) to measure an individual's experiential connection to nature and found the connection to nature as an important predictor of ecological behavior and subjective well-being. According to them, CNS having good psychometric properties could be regarded as a promising tool for research on the relationship between humans and the natural world. Nature-relatedness could also act as a significant predictor of human happiness and environmental sustainability (Zelenski & Nisbet, 2014).

While exploring health benefits, strong evidence was found linking biodiversity with the production of ecosystem services, nature exposure, and human health (Sandifer *et. al*., 2015). Fuller *et. al*. (2007) asserted that psychological health benefits enhanced with the level of species richness of urban green spaces. On the contrary, a lack of consistent relationship was found by Dallimer *et. al*. (2012) between the psychological well-being of urban green space visitors and actual species richness but well-being was found to be positively related to the richness that the green space users perceived to be present. Coldwell & Evans (2018) reported that visits to urban green space and countryside related positively to mental well-being while city size and the intensity of urbanization had negligible influence. Biodiversity knowledge did not moderate the association between human well-being and green space visit rates. In a descriptive study by Armstrong (2000) on community garden programs, it was revealed that the most common reasons for visits to community garden programs were access to fresh foods, enjoying nature, and corresponding health benefits.

A positive relationship was found to exists amongst human health (mental and physical), psychological well-being, and nature connectedness as well as between actual and perceived botanical richness (Southon *et. al*., 2018).

DISCUSSION

With an intention to analyze the state of the art of research on perceptions of biodiversity, the review collected, collated, and assessed empirical data on perceptions of biodiversity, particularly in urban green spaces.

Overall, the review findings determine that biodiversity knowledge has a greater influence on preference to biodiversity and support for its conservation. Most of the studies demonstrate that though species literacy rate is low amongst the general public compared to subject matter experts, people value biodiversity and it is found to be positively associated with their preferences. It is also established that regular visitors of the green spaces have higher species identification skills thus establishing a positive association between species literacy and visitation rates. Nevertheless, Fuller *et. al*. (2007) and Dallimer *et. al*. (2012) have identified contradictory shreds of evidence related to how correctly the general people can assess biodiversity. Research works demonstrating the correlation between perceived and actual biodiversity (Fuller *et. al*., 2007; Qiu *et. al.*, 2013) found that people most often underestimate biodiversity (Dallimer *et. al*., 2012).

The findings also determine that people prefer biodiversity in urban green spaces for its recreational benefits. It is evident that people associate recreational benefits with their sensory perceptions in urban green spaces. Thus, the pressure on urban green spaces to serve both the functions of recreation as well as conservation is much higher as recreational activities are often found to conflict with biodiversity conservation (Young *et. al*., 2005). Hence it becomes significant for the managers and policymakers of the green space to

understand the correlation and trade-off between the space utilized for site facilities and amenities and the space utilized for green and natural features.

Many researchers have shown interest in studying public awareness and support for biodiversity conservation, particularly the attitude of the public towards the management of biodiversity. The findings reveal that public support for biodiversity conservation is associated with the benefits people derive from biodiversity. This could largely be ascribed to a lack of ecological knowledge and the misconceptions related to the ecological principles that act as major constraints for biodiversity conservation. Moreover, people's support for biodiversity conservation is also discovered to be strongly associated with their origin and level of education (e.g., Vodouhê *et. al.*, 2010), where urban people are found to be more supportive towards conservation practices compared to the rural population. People's biodiversity perceptions, awareness, and conservation support can contribute positively to environmental policies and decision-making and thus should form the basis for urban planning and management (Illiassou *et. al*., 2016).

It is also evident from the study that perception and preference regarding biodiversity greatly differ amongst various socio-demographic sub-groups and found to increase with age and educational level. Thus, promotion of biodiversity awareness at the school level through exploratory learning activities as suggested by Matthies & Bose (2008) are felt to be of utmost importance and should become part of formal education.

The visitation rate is found to be varying amongst population sub-groups, e.g., between young and older people as well as males and females. Visitation frequency is also found to be much higher at larger green spaces which fascinate visitors from farther distances. The studies also reveal that people having a greater degree of nature connectedness prefer a higher level of vegetation cover and tend to visit the urban green spaces more frequently which also conforms to the study done by Lin *et. al*. (2014). Alike biodiversity conservation support, preference for biodiversity also varies greatly amongst population sub-groups based on the benefits derived. Thus, the review directs that efforts should be made to increase the visitation frequency of public to urban green spaces which can assist in enhancing their biodiversity knowledge and promote interest in green spaces resulting in greater conservation support.

Maximum research work regarding biodiversity perception has been carried out on the quality and characteristics of vegetation more specifically species richness (28 %). Though people mostly underestimate species richness, species characteristics significantly affect biodiversity perception. The research works vis-à-vis how human responses to various types of natural landscapes has increased the likelihood that most natural landscape might not always be the most preferred one. Furthermore, it is found that people find natural ecosystems often less attractive than manicured environments (e.g., Kathryn *et. al*., 2002). But there are certain contradictory pieces of evidence as well (e.g., Žlender & Thompson, 2017), where it is discovered that there lies a strong cross-cultural preference for green spaces which are semi-natural as compared to the formal parks. Also, actual botanical richness at meadow style planting is found to be strongly linked with perceived botanical richness indicating that people prefer and appreciate meadow style planting (e.g., Southon *et. al*., 2017 and Hoyle *et. al*., 2017a). Researchers (e.g. Palliwoda *et. al.*, 2017) recommended several approaches for enhancing biodiversity that include maintenance of the traditional management of meadows, converting lawns into species-rich meadows, and planting shrubs with edible fruits.

Regarding restorative benefits of biodiversity, the findings demonstrate that people largely find biodiversity as restorative and seek numerous health benefits from urban green spaces including physical, mental, and psychological well-being. Though aesthetic preference is

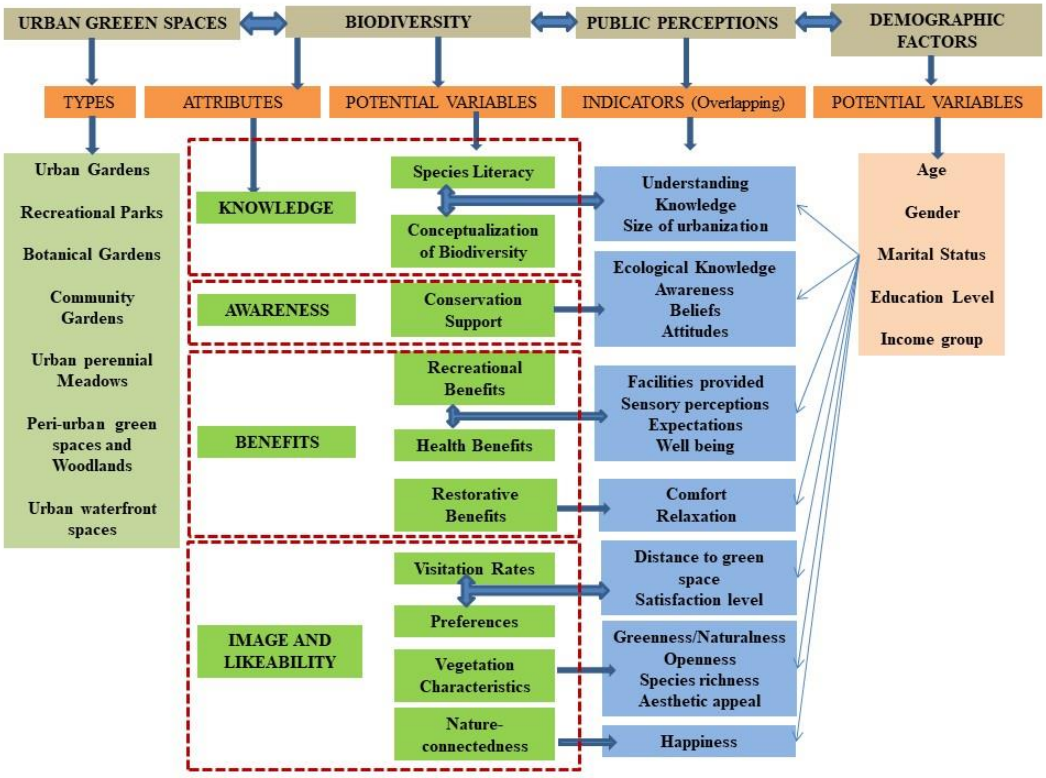
found to be unrelated to age and gender, people find scenic beauty and natural planting more restoring and relaxing. Thus, as described by Van den Berg *et. al*. (2014) restoration in urban public spaces depends not only on individual perceptions but also on the physical characteristics of the setting. Hence, as suggested by Wood *et. al*. (2018), to gain restorative benefits from nature, there is a need to increase the number of urban green spaces, improve vegetation cover with botanical and floral diversity, and enhance species richness and biological complexity within.

Though people only appreciate benefits that are immediately apparent in a general sense (Montgomery, 2002), the studies indicate that people are not completely disconnected from experiencing biodiversity in urban green spaces and still perceive and appreciate species richness present within. Overall, it is observed that vegetation characteristics like planting structure, flowering, quality, and quantity of vegetation have a greater influence on perceptions of biodiversity.

The results across all the studies related to nature connectedness amongst laypeople show that people's orientation towards nature is more often positively related to their preference to biodiversity and visitation rates to the green spaces. Apart from this, people with higher eco-centricity prefer high species richness and tend to identify species more accurately. Significant associations are also found to exist amongst perceived biodiversity, nature connectedness, and self-estimated mental health and psychological wellbeing. It is not just the psychological health but physiological health is also found to be improved with exposure to biodiversity Thus, cultivating and enhancing nature connectedness can prove effective in increasing human happiness and environmentally sustainable behavior (Zelenski & Nisbet, 2014).

The above analysis and synthesis of empirical findings ultimately assisted in identifying the attributes of biodiversity in urban green spaces, their potential variables and corresponding public perception indicators. These potential variables are found to be interdependent. In addition, though each biodiversity variable is strongly associated with certain human perception indicators, sometimes these perception indicators are found to be overlapping amongst the biodiversity variables. The study led to the understanding of the interrelationships between these factors that have been demonstrated in the proposed framework for studying biodiversity perceptions (Figure 4).

Fig. 4: Proposed framework for studying human biodiversity perceptions in urban green spaces



METHODOLOGICAL STRENGTH AND WEAKNESS OF THE RESEARCH

Looking at the large number and types of spaces studied, it could be derived that the review provides a sound base for generalization of the findings at the local scale. The broader geographical coverage of the studies, which comprises 22 countries located on different continents allows for further generalization of the findings at a global scale. Furthermore, the review collects data from papers that have studied a wide array of urban green spaces and a variety of on-site and off-site data collection methods. At the same time, numerous variables relating to nature and biodiversity have been studied in the papers which further enhance the generality of the review. Most of the studies used observational methods focusing on the analysis of the actual characteristics of biodiversity and species richness and human perceptions rather than relying upon experimental researches in controlled conditions. Thus, the findings across the studies become much more significant for generalization. Having said that, it is also found that no substantial research work has been carried out on the perceptions of biodiversity in countries of Africa and the Global South. The study also indicates that the researchers have been much interested in perceptions studies of plant species and greatly ignored animal species that contribute to a significant limitation of the present state of research on perception studies of biodiversity, more specifically, in urban

green spaces. Likewise, biodiversity perceptions of waterfront urban spaces particularly riverfronts, lakefronts, etc. also demand greater attention.

The review has some limitations that could be addressed by future researchers. Firstly, the search strategy includes papers published in the English language only as accurate identification and evaluation of research papers in languages other than English were not feasible. Thus, the articles written in languages other than English and other scholarly sources like book chapters are excluded from the review.

Moreover, it is realized that a large amount of scholarly work has been carried out on urban biodiversity and species richness within whereas fewer works are found to be focusing on human perception of urban biodiversity. This results in the inclusion of relatively lesser research papers in this review. This data limitation could be addressed in future systematic review papers by expanding the search and incorporating research works in other languages and from other sources of literature.

Cultural, political, historical, and environmental factors vary greatly across the world. Some more studies exclusively focusing on the effect of these factors on human perception of urban biodiversity might help urban planners and managers to frame and adopt suitable policies for green space development and management.

CONCLUSIONS

The paper attempts to review the triangular relationship between urban green spaces, biodiversity, and users' perceptions. It is well established from the study that the urban green environment and biodiversity within is greatly appreciated by the users as it offers various benefits in the form of recreation, health, and restoration. At the same time, it also renders unique prospects for the conservation of biodiversity.

However, it could be concluded that there is a necessity for a few more interdisciplinary studies for further investigation of the people–biodiversity connections which would assist in revealing the role of urban biodiversity in people's day-to-day life. It is also felt that to produce stronger evidence, more research work incorporating various other social groups particularly, targeting gender and age differences is sought for. Future studies at other geographical regions and other types of urban green spaces particularly waterfront spaces are also desirable where a negligible contribution has been identified. The research gap is also identified in terms of perceptions of various other taxonomic groups apart from plants like animals, mammals in particular. Future research could also target upon exploring various opportunities of conserving the biodiversity in urban green spaces through public support which could help in the development of advanced ways of conservation and promotion of urban biodiversity.

As such, the growing urbanization has resulted in the present urban societies that are greatly detached from the natural environment which entails higher services from urban green spaces looking at their enormous contribution towards the urban quality of life. Thus, to design and manage urban green infrastructure, there is an urgent need to understand public experiences of nature and how people conceptualize physical, social, psychological, and spiritual services rendered by urban nature.

CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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