



PARTICIPATORY ECOSYSTEM SERVICES ASSESSMENT OF HIGH CONSERVATION VALUE URBAN FOREST: LESSONS FROM DELHI RIDGE

Bhuvan Chopra^{*1}, Y.S.C. Khuman² and Shalini Dhyani³

¹Delhi University, Delhi, INDIA

²School of Interdisciplinary and Transdisciplinary Studies,
Indira Gandhi National Open University, New Delhi, INDIA

³Critical Zone Group, Water Technology and Management Division, CSIR-NEERI, Nagpur (MS) INDIA

Research Paper

Received: 13.05.2024

Revised: 21.05.2024

Accepted: 04.06.2024

ABSTRACT

Rapid urbanization has posed multiple environmental challenges for urban planners and policy makers. There is growing relevance of green spaces in urban areas as a Nature based Solution in decision making process. Ecosystem services provided by the urban green areas play a pivotal role in enhancing the physical and mental well-being of the urban dwellers. Present study is a participatory effort to understand perspectives of urban residents about ecosystem system benefits from urban green spaces. Study was carried out at Delhi Ridge, despite being high value urban ecosystem for Delhi it is severely stressed from diverse drivers of biodiversity loss that has resulted in enhanced encroachment by non-native species. Some parts of Ridge are converted into semiwilderness parks with pathways and are popular among morning walkers and other visitors. Our study revealed more than 70.93% of the respondents preferred Delhi Ridge for daily walks than any other neighbourhood parks as they considered the place has better greenery, diversity of plants, animals, provides fresh air and peaceful environment for mental relaxation and psychological benefits. 51.23% of them considered Delhi Ridge as an excellent place for nature education to next generation. Survey result indicated that 46.66% of them were willing to pay green tax for access to Delhi Ridge. The study provides clear interest of urban residents towards healthy urban green spaces that requires financial support for protecting their original structure and also to prioritise restoration for replacing non-native species and ensuring nature's contributions for human well-being.

No. of Pages: 11

References: 44

Keywords: Delhi Ridge, Ecosystem Services, psychological benefits, place-based attachment, sustainability, Urban green spaces.

INTRODUCTION

Globally, urbanization has become a dominant phenomenon dramatically transforming the biosphere (Boivin et al. 2016). Between 1990 and 2015, the expansion of urban areas in developed nations in relation to urban population growth increased by a ratio of 1.5 (UN World Cities Report 2020). It is expected that 68% of world population will reside in urban centres by 2050 (United Nations 2018). With increase in payload of urban

environmental risks, the idea of urban resilience has been galvanized among the policy makers and administrators (Borie et al. 2019). The Sustainable Development Goal 11 (SDG 11) drives for sustainable, inclusive, safe and resilient cities with extensive focus on climate change adaptations and disaster risk reduction. Therefore, there is need for sustainable, planned urbanization with improved quality of life and enhanced social and environmental inclusion. Urban green areas can play a pivotal role in

*Corresponding author: bhuvanchopra123@gmail.com

equipoising some challenges linked with rapid urbanization. According to WHO, urban green spaces are green areas covered with vegetation and are an important part of green infrastructure providing opportunity to city dwellers to get in contact with nature. Urban green areas include urban parks, gardens, lawns, walkaways, green belts, avenue trees, grasslands, wetlands along with natural forests within the city scape (Hadavi, Kaplan and Hunter 2015; Farahani and Maller 2018).

Urban green spaces provide numerous ecosystem services to the city dwellers beside fostering urban resilience (Dhyani *et al.* 2018). These services range from pollution control to climate regulation, habitat for urban biodiversity, carbon sequestration, run-off control to providing recreational benefits along with ensuring social and psychological wellbeing of the urban residents (Haq 2011; Green *et al.* 2016). Ecosystem services from urban green spaces bear a significant impact on urban life quality and must be integrated in urban land use planning and management mechanisms (Bolund and Hunhammar 1999; Ruiz-Luna *et al.* 2019; Semeraro *et al.*, 2021; Dhyani *et al.* 2022). These services help in addressing urban environmental problems making cities increasingly sustainable (Babí Almenar *et al.* 2021).

Multiple studies herald the benefits of urban green spaces and ecosystem services stemming from them. Urban trees are known to provide air pollution control benefits (Pace *et al.* 2020) along with cooling effect due to transpiration (Rahman *et al.*, 2020; Tan and Shibata 2022). Moss *et al.* (2019) studying evaporative cooling by urban forests in UK has found that urban cooling benefits obtained from trees have an annual valuation of £84 million. Lahoti *et al.*(2020) studied the vegetation structure along with species composition and carbon sink potential of urban green spaces of Nagpur city. Similarly, Dhyani *et al.* (2021) underlined the carbon storage potential of trees located in Seminary Hills urban forest in Nagpur.

Urban green spaces are linked to innumerable health benefits that range from physical health (green exercises) to a variety of psychological, emotional and mental health benefits (Lee and Maheswaran 2011; Song *et al.* 2014; James *et al.* 2016). Green exercise (physical activities in natural presence) has positive impacts on self-esteem in humans (Barton and Pretty 2010). Nature connectedness is directly correlated to human well-being and is mediated by place attachment (Basu, Hashimoto and Dasgupta 2020). Interaction with the nature- whether walking in natural areas or mere viewing the nature-based

pictures can help in improvement of directed-attention abilities (Berman, Jonides and Kaplan 2008). Urban green spaces have motivational effect on city dwellers besides relieving stress and uplifting their mood (Dasgupta *et al.* 2022). MacKerron and Mourato (2013) explored the linkage between momentary subjective wellbeing and immediate environment settings of a person comparing urban settings and natural environment within U.K. The participants were found to be happier in natural habitats as compared to the urban settings. In a perception study related to urban green spaces in Delhi, Bhattacharya *et al.* (2019) has reported that 58% of respondents strongly agreed that the visiting these green spaces relieves them of stress and have positive impact on their lifestyle. Wang *et al.* (2020) found that relaxation and rest is the most prominent of all reasons given by respondents regarding use of small urban green space in Shanghai, China.

Delhi, the capital city of India has witnessed high rates of urbanization due to rapid increase in population. The decadal population growth between 2001 and 2011 stands at 21.20% (Delhi Planning Department). Delhi has also witnessed unprecedented episodes of air pollution in past few years posing potential risk for the health and well-being of the residents (Talukdar *et al.* 2021). On the flip side, Delhi has 20% green cover and more than 18,000 parks and gardens spread in about 8,000 hectares making the city one of the greenest capitals in the world (Delhi Parks & Garden Society). The green spaces may bear some countering effect on all the environmental challenges faced by the city reducing its ecological footprint.

Considering the background of the context present study was designed to explore place-based attachment of people to urban green spaces and relevant ecosystem services they harness from these spaces. Study was designed under following objectives:

Understanding the complexities of human-green space interactions, place-based attachment to support mainstreaming of urban blue-green infrastructure as a potential naturebased solution in urban policies.

Understanding the perspectives of urban residents towards urban green spaces and their interest in green interventions for ensuring conservation and restoration of fast expanding urban green spaces This study tries to set a reference framework for policy developers to integrate the holistic views of urban residents in designing the new policies and strengthening existing policies related to urban greens in wake of increased threat from climate change and

other environmental risks. The key findings of this study will also bear positive implications in designing and maintenance of other green infrastructure in the city.

MATERIAL AND METHODS

Study Area

Delhi, the capital city of India, is also the second largest urban conglomeration in the world. It is located between 28°22' to 28°24' N and 76°48' to 77°23' E and has two prominent geographical features- River Yamuna and Delhi Ridge. Delhi lies in subtropical zone with very hot and dry summers which span from April to June. The annual Monsoon sets in the month of July and lasts till September and gives major share of rains to the city. The annual rainfall of the city is equivalent to 762.3mm (IMD). Winter season is short and mild and range from December to February.

Delhi Ridge (Figure.1) is the extension of Aravalli hill ranges that are 1.5 billion years old. Once more or less adjoining, because of increase in population pressure and rapid urbanization, Delhi Ridge at present is divided into four distinct parts- Northern Ridge (87 hectares), Central Ridge (864 hectares), South Central Ridge (626 hectares) and Southern Ridge (6200 hectares). Various agencies which include Delhi Development Authority (DDA), Forest Department of Delhi, Municipal Corporation of Delhi (MCD) and Central Public Works Department (CPWD) are involved with managing four regions of Delhi Ridge. The Ridge is threatened from diverse direct and indirect drivers of biodiversity loss that range from encroachments, dumping of waste, infrastructure construction, invasion by non-native species



Figure 1: Map of Delhi showing four segments of Delhi Ridge.

etc. According to Champion and Seth, 1968, Delhi Ridge's main vegetation is dry tropical thorn forest dominated by Acacias and other thorny species. The main species are-*Acacia catechu*, *Acacia modesta*, *Acacia leucophloea*, *Acacia senegal*, *Anogeissus pendula*, *Diospyros montana*, *Balanites aegyptiaca*, *Wrightia tinctoria*, *Butea monosperma*, *Prosopis cineraria* etc. However, at present all the four parts of Ridge is dominated by a non-native tree species *Prosopis juliflora*, brought from South America in early 60's during social forestry programme (Shukla, Basu and Singh 2014; Sharma and Chaudhry 2018).

Some parts of Delhi Ridge are converted into parks with semi-wilderness environment and are accessible to general public. These areas are especially popular among morning and evening walkers and include parts of Northern Ridge or Kamla Nehru Ridge, Buddha Jayanti Park and Bhulli Bhatiyari Park in Central Ridge, Sanjay Van in South-Central Ridge and Hauz Rani City Forest, Jahapanah City Forest and Sainik Farms in Southern Ridge. In our present study, we have considered Northern Ridge (Kamla Nehru Ridge), Buddha Jayanti Park in Central Ridge, Sanjay Van in South-Central Ridge and Hauz Rani City Forest in Southern Ridge for taking samples.

Data Collection

Participatory survey using semi structured questionnaire was used followed by data collection from August 2021 to January 2022. An online questionnaire was prepared using Google Forms that was circulated among potential respondents through email and WhatsApp groups of morning walkers.

Wherever possible, data collection through face-to-face interaction was employed that also helped having focused discussions on the topic too. The respondents were randomly selected in such a case in the field without any prior set preference. As strict Covid-19 regulations were in place during some part of the study period, telephonic interviews were also carried out. A total of 203 samples (n=203) were collected. Maximum samples were collected from Central Ridge area (n=63) followed by Northern Ridge (n=59), South-Central Ridge (n= 45) and Southern Ridge (n=36). Also, age, education, income, occupation along with other background information was collected from the respondents. The questionnaire included both open and close ended questions for fetching the varied range of responses from the respondents. Likert statements were also employed to capture people's perception related to various provisioning ecosystem services (viz. fuelwood/fodder) and non-material benefits (viz. air pollution control, ground water recharge, habitat for

birds and animals, psychological benefits or mental relaxation, bird-watching, nature education etc.) visiting the forests of Delhi Ridge. Likert statements were used to gauge wide ranging perception of people starting from “Completely/Strongly Disagree”, “Disagree”, “Slightly disagree”, “Slightly agree” to “Agree” and “Completely/Strongly Agree”. Questions related to improving the status and ecosystem health of Delhi Ridge were also asked. Interests towards Payment for Ecosystem Services (PES) in form of a green tax for using the intangible benefits from the forest of Delhi Ridge and the preferred amount was also enquired. As some respondents were not well versed with English language, the questions were first translated into local Hindi language and accordingly responses were recorded. The responses were analysed and interpreted.

RESULTS & DISCUSSIONS

Large inflow of visitors was observed in early morning and late evening hours and also on national and religious holidays to Delhi ridge. Numerous socializing groups have been formed by the visitors which occasionally get involved in recreational activities that range from jogging, yoga and other physical activities including outdoor games such as volleyball and badminton. Delhi Ridge is also a popular destination for bird watchers and nature enthusiasts. However, some portions of Delhi Ridge have been frequented by antisocial elements and thus avoided by public in large. Our experience and study have brought forth myriad of responses from the visitors of Delhi Ridge but a common observation made in all the cases is that a very strong sense of place attachment exist in most of the cases. Most people opined that this place and its natural bounty cannot be found elsewhere in Delhi region. In today's busy world, Delhi Ridge provides an escape for those who

seek tranquillity in urban scape and this phenomenon has been reported by other parts of the world as well (Shao and Liu, 2017; Basu *et al.*, 2019).

Respondents of our survey belonged to different age classes that is presented in Table1. Number of respondents falling in different age class is also presented in Table 1. Maximum number of respondents (45.32%) belonged to young age group of 18 to 35 years, followed by 36-55 years (33.49%) while least were from the age group of above 75 years (0.98%). That also means a lot of visitors to the study area belonged to younger age groups and less from elderly generation. Spread of Covid-19 might be one of the reasons to have less number of respondents as data collection was largely spread across these months. Out of 203 respondents, 123 (61%) were males while 80 (39%) were females. Maximum number of respondents were graduates (51.72%) followed by post graduates (33.0%) while least were represented under uneducated or illiterate class (0.49%). The respondents were also asked about the distance they travel (in Kms) from their home to reach Delhi Ridge (Table 2). It was evident that most visitors travelled 0 to 5 kms (49.75%), followed by 6-10 Kms (24.13%) while around 12.80% visitors travelled more than 50 kms to reach Delhi Ridge. Daily access to the urban green space is largely dependent on the distance being travelled by visitor and it also limits regular visits to harness the benefits. Regarding frequency of visit, majority of respondents (33.49%) were everyday visitors to the Ridge while 30.04% visitors came here few times a week whereas, 20.19% visitors visited the green spaces for the very first time. According to Zhang *et al.* (2015) increase in visiting frequency helps in fostering social relations thus increasing place attachment among visitors.

Table 1: Age of respondents.

S.No.	Age Groups	No. of Respondents	Percentage
1	18-35	92	45.32
3	36-55	68	33.49
4	56-75	41	20.19
5	Above 75	2	0.98
	Total	203	

Regarding purpose of visit to the Ridge, most of the respondents visited the Ridge for recreational purpose (66.50%) followed by educational visits (9.35%) and a limited 0.49% respondents visited for diverse provisioning benefits that included collection of dry

fuelwood, fodder or foraging of medicinal plants and wild edibles. Among recreational activities as cultural benefits from Delhi Ridge, most respondents used morning or evening times for walks (70.44%), followed by observation of plants, nature (16.25%),

bird watching (7.38%) and also sometimes excursions organised for students (3.94%). 0.49% percent of the

respondents also informed visiting the Ridge for cleanliness drive or picnic.

Table 2: Distance travelled by visitors to reach Delhi Ridge.

Distance in Kms	No. of Respondents	Percentage
0 to 5	101	49.75
6 to 10	49	24.13
11 to 15	17	8.37
16 to 20	10	4.92
More than 20	26	12.80
Total	203	

When asked about their experience visiting the Ridge (Figure. 2), majority of the respondents shared their experience to be excellent (41.37%) followed by good (45.81%), while 2.95% of the respondents claimed that their experience was highly unpleasant. The reason given for unpleasant experience was presence of some anti-social elements in the Ridge. We also found that there is slight more percentage of female respondents

(3.75%) that have reported their experience as highly unpleasant when compared to male respondents (2.43%). According to Rigolon *et al.* (2019) safety plays an integral role in determining the quality of urban green spaces and women are less likely to visit those spaces that are perceived insecure as compared to men.

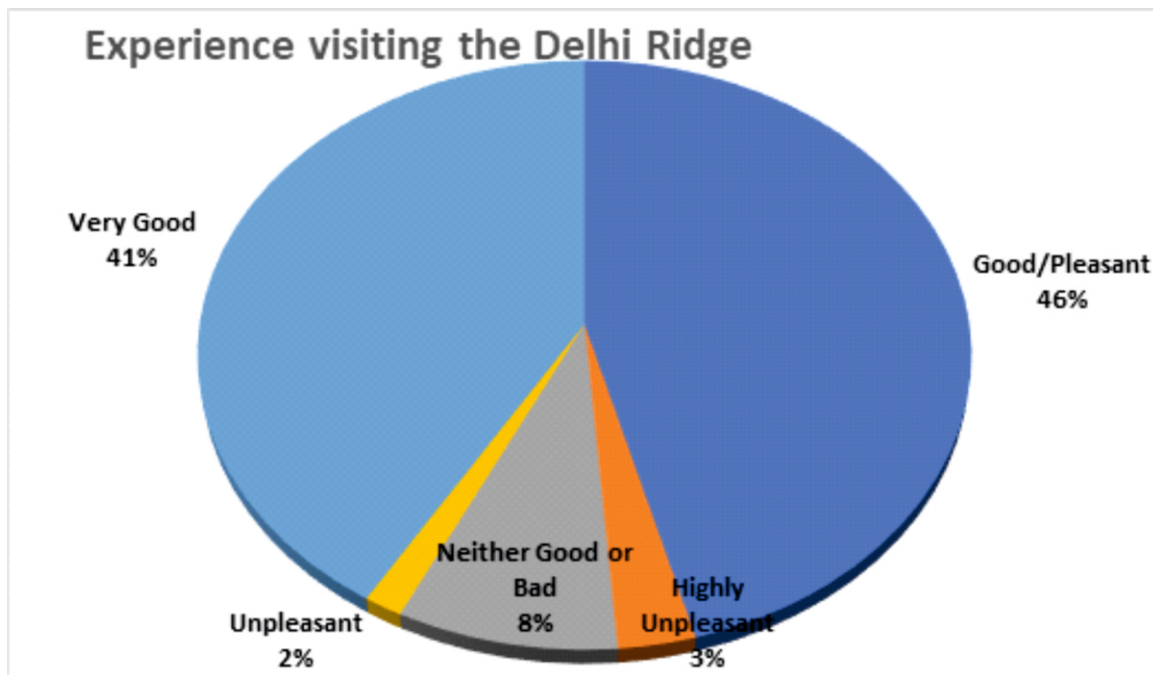


Figure 2: Experience of the visitors visiting Delhi Ridge.

In the survey respondents were also asked whether they preferred Delhi Ridge over any other neighbourhood parks for morning or evening walks to which majority of them (70.93%) said “Yes” while only 8.37% said “No” while there were another 14.28% respondents said “May be” for this question. It was because of surrounding environment having more greenery, peace and fresh air that made them prefer

Delhi Ridge than any neighbourhood park. On being asked if they will refer others for visiting the Ridge around 85.71% said “Yes” and 4.4% said “No”. Majority of the respondents perceived that because of better greenery, clean air and peaceful environment they will refer this place to others too so that they can also get benefitted of the cultural ecosystem benefits of Delhi Ridge. Some respondents also opined that this

place has good diversity of plants and animals and that's why they want others also too to come here. Larger urban green spaces provide ample functional space and aesthetics thus prompting users to travel larger distances and spending more time (Biernacka and Kronenberg 2018). Beside this, the diversity in nature and green spaces are known to promote physical and mental well-being in humans (Aerts, Honnay and Van Nieuwenhuysse 2018).

Most of the respondents considered Delhi Ridge to be green lungs for Delhi and it helps in air pollution control. 55.17% of respondents believed Ridge to be efficient and another 32.51% mentioned Ridge is efficient in controlling pollution. The reason given by respondents is that they perceive the area to be greener and has more pollution controlling ability. 9.35% were unsure about this question and were unable to comment on the pollution control ability of Delhi Ridge while only 2.95% believed that Ridge is not efficient in air pollution control. 84.72% respondents firmly believed that Delhi Ridge plays an important role in addressing the environmental problems of Delhi while 1.47% were against this thought.

To the question about changes they have observed in Delhi Ridge in past 10 years 59.60% respondents confirmed that Delhi Ridge has changed in last 10 years. When prompted to elucidate the changes they have observed they provided diverse responses. Some mentioned that greenery has increased along with more amenities and pathways for walkers indicating that forests have been opened up and is now more accessible for public and new ornamental plants have been added to the ridge. Authors had similar observations in some regions of Delhi Ridge. A few others believed that the area has seen degradation of forests and loss of native species over the decades. 34.97% respondents said were not confident to comment on any changes that have occurred in Delhi Ridge while only 5.41% said that they have not observed any changes in the region in last 10 years. To the question on suggestions for overall improvement

of Delhi Ridge forest, majority 21.67% opted that ecological restoration can be a better approach to implement. Although, in most cases users were not well versed with the terminology and were made to understand about the concept of restoration. Around 15.76% of users believed in regular monitoring and patrolling of the area against human intrusions while 3.94% opted for fencing and construction of proper boundary. 11.82% users opted for all the above three mentioned solutions while 14.77% users believed that ecological restoration and regular monitoring & patrolling will be sufficient. Only 1.97% of users were in favour of converting the forests into park. Even 9.35% users favoured application of all the four aforementioned solutions given to them. Some users also stressed on making Delhi Ridge a no-plastic zone and removal of all the plastic waste material from the area.

Users were given various statements so as to deduce an array of perceptions regarding ecosystem services derived from the forests of Delhi Ridge using Likert scale (Table 3). For the statement- "Delhi Ridge helps in controlling air pollution." More than half (51.72%) respondents completely agreed while miniscule 0.49% showed complete disagreement. Around 9.8% users showed complete agreement, 19.21% respondents showed agreement that Delhi Ridge provides provisioning benefits like fuelwood and fodder while 28.07% respondents were only in slight agreement to this statement. As most respondents were from middle and upper-middle class background, they perceived that collection of fuelwood may destroy the forests and therefore were in less agreement with the statement. More than half (53.20%) of the respondents were found to be in complete agreement with the statement that "Delhi Ridge provides habitat for birds and animals" while 48.27% completely agree that "Delhi Ridge provides for ground water recharge" and can help in controlling urban flash floods and water logging during monsoons.

Table 3: Likert statements and percentage of responses.

S.No.	Statements	Completely/ Strongly Disagree	Disagree	Slightly disagree	Slightly agree	Agree	Completely/ Strongly Agree
1	Delhi Ridge helps in controlling air pollution	0.49%	5.41%	2.46%	16.25%	23.64%	51.72%
2	Delhi Ridge provides fuel wood and fodder.	10.83%	14.28%	17.73%	28.07%	19.21%	9.85%
3	Delhi Ridge provides habitat for birds and animals.	1.47%	2.95%	3.44%	13.79%	25.12%	53.20%

4	Delhi Ridge provides for ground water recharge and help in local flood/ water logging control during monsoons.	1.97%	4.92%	4.43%	15.27%	25.12%	48.27%
5	Delhi Ridge helps in decreasing the stress and provides mental relaxation.	1.97%	1.47%	3.44%	13.30%	18.71%	61.08%
6	Delhi Ridge is a perfect spot for bird-watching.	1.97%	5.41%	7.38%	17.73%	22.16%	45.32%
7	Delhi Ridge plays a vital role in nature education.	0.98%	2.95%	4.92%	17.24%	22.66%	51.23%
8	Protection of Delhi Ridge will help in solving Delhi environmental problems and helps in making Delhi sustainable.	0.985%	1.47%	4.43%	12.31%	23.64%	57.14%
9	Visiting Delhi Ridge, makes me feel closer to nature.	0	2.89%	2.89%	8.69%	14.49%	71.01%

In case of cultural ecosystem services such as psychological benefits, mental relaxation the percentage increased to around 61.08% when respondents ranked the statement that Delhi Ridge helps in decreasing the stress and provides mental relaxation. 51.23% completely agreed that Delhi Ridge plays a vital role in nature education. Around 45.09% respondents completely agreed that Delhi Ridge is a perfect spot for bird watching. 71.014% respondents strongly believed that visiting Delhi Ridge makes them feel closer to nature and gives them place based attachment while 57.14% respondents have strong agreement that protection of Delhi Ridge will help in solving Delhi environmental problems and make Delhi a sustainable city as per SDG 11.

A strong perception of closeness towards nature and place-based attachment was observed and experienced by most of the respondents visiting the Delhi Ridge and was stressed in the responses to open ended questions of the study. Most of the respondents are of the view that serene natural surroundings of Delhi Ridge help them forget the hustles of daily life and bring inner peace and tranquillity. They perceive that walking in the fresh air of the forests give more oxygen and alleviate stress. They feel strong sense of place-based attachment towards Delhi Ridge and also associate this area with high diversity of plants and birds, which are not found anywhere else in Delhi although on the contrary they may not have knowledge about the plant and animal species found

in the region. There are several contemporary studies that validate that people favor frequenting green spaces with more biodiversity and natural elements that also fosters connectivity to nature and overall well-being (Southon et al., 2017; Cameron et al. 2020). Our study findings endorse the same.

[Response 1] *I love the Aravalli's flora.* [Response 2] Green environment of Delhi Ridge makes me feel connected to nature. [Response 3] I come here to get more fresh air and to explore nature. [Response 4] It is more natural than parks, parks seem to be artificial. [Response 5] I love the nature, I get the fresh air, I love watching birds, when I go to the walk, I get peace in my soul.

It was interesting to note that 46.66% respondents were found willing to pay a green tax for accessing the forests of Delhi Ridge as PES while 33.33% responded answered in may be to this question. 20% of respondents were however not in favour of paying any kind of such green tax (Figure. 3). These results were in line to the observations made by Gandherva, Bhattacharya and Bhattacharya (2019) in their study related to urban greens of Delhi. When asked how much green tax they were willing to pay most respondents (58.33%) were in favour to pay a tax of Rupees 5 to Rupees 10 (0.067 USD to 0.13 USD) while 8.33% favoured paying Rupees 11 to Rupees 20 (0.15 USD to 0.27 USD). Around 16.66% were in favour of paying Rupees 50 to Rupees 100 (0.67 USD to 1.33

USD) while equal percentage of respondents were inconclusive on how much money should be paid as green tax.

ARE YOU WILLING TO PAY A GREEN TAX FOR ACCESSING DELHI RIDGE FOREST

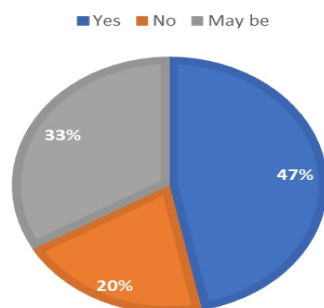


Figure 3: Responses of people regarding their willingness to pay a green tax for accessing the forest of Delhi Ridge.

CONCLUSION

The relationship between humans and green spaces is often intricate, dynamic and multi-dimensional in nature (van Riper *et al.*, 2019; Cardou *et al.*, 2020). Urban planners are increasingly realizing the importance of inclusion of natural green scapes and green infrastructure in present and future planning assignments but at the same time it is imperative to see these spaces in context of social dimensions also. The present study has brought forth the diversity of perceptions related to Delhi Ridge forests. Although roadblocks have been encountered as some respondents were not keen to share their income or address, also covid protocols have restricted the face-to-face interactions during the study period. However, the study has brought forth the relevance of Delhi Ridge in terms of cultural services such as bird watching, nature education, stress control, mental relaxation, closeness to nature along with some regulating ecosystem services such as pollution control and ground water recharge. With 61.08% of users completely agreeing on the role of this area in controlling stress and providing mental relaxation is reflective of significance Delhi Ridge holds in people's life. This study has brought forth the underlying dynamics of people association with this place and a step forward towards understanding this complex relationship.

Our study has also underpinned the significance of protection of Delhi Ridge in addressing Delhi's environmental problems and public views on how to make the city more sustainable and resilient in wake of deepening ecological crises and potential environmental risks. At the same time, the study has

brought forth the views regarding acceptance of WTP among masses for accessing the forests of Delhi Ridge. Moreover, the study has underlined the need for conservation of Delhi Ridge through ecological restoration rather than conversion into park. Most of the people are in favour of bringing back native flora which once inhabited this region. This will help the policy makers in designing suitable policy framework and plan of action for long-term conservation of Delhi Ridge.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

Authors are thankful to authorities of DDA, Centre for Environment Management of Degraded Ecosystems (CEMDE), Forest Department and CPWD for their support during the study period.

REFERENCES

1. **Aerts, R., Olivier, H., and Nieuwenhuyse, A.V.** (2018): Biodiversity and Human Health: Mechanisms and Evidence of the Positive Health Effects of Diversity in Nature and Green Spaces, *British Medical Bulletin*, 127(1):5-22. <https://doi.org/10.1093/bmb/ldy021>.
2. **Babí Almenar, J., Elliot, T., Rugani, B., Philippe, B., Navarrete Gutierrez, T., Sonnemann, G., and Geneletti, D.** (2021): Nexus between nature-based solutions, ecosystem services and urban challenges, *Land Use Policy*, 100:104898. <https://doi.org/10.1016/j.landusepol.2020.104899>.
3. **Barton, J.O., and Jules P.** (2010): What is the Best Dose of Nature and Green Exercise for Improving Mental Health? A Multi-Study Analysis, *Environmental Science & Technology*, 44 (10):3947-3955. <https://doi.org/10.1021/es903183r>.
4. **Basu, M., Shizuka, H., and Rajarshi D.** (2019): The Mediating Role of Place Attachment Between Nature Connectedness and Human Well-Being: Perspectives from Japan, *Sustainability Science*, 15(3):849-862. <https://doi.org/10.1007/s11625-019-00765-x>.
5. **Berman, M. G., Jonides, J., and Kaplan, S.** (2008): The Cognitive Benefits of Interacting with Nature,

- Psychological Science, 19(12):1207-1212. <https://doi.org/10.1111/j.1467-9280.2008.02225.x>.
6. **Biernacka, M., and Kronenberg, J.** (2018): Classification of Institutional Barriers Affecting the Availability, Accessibility and Attractiveness of Urban Green Spaces, *Urban Forestry & Urban Greening*, 36:22-33. <https://doi.org/10.1016/j.ufug.2018.09.007>.
 7. **Boivin, N.L., Zeder, M.A., Fuller, D.Q., Crowther, A., Larson, G., Erlandson, J.M., Denham, T., and Petraglia, M.D.** (2016): Ecological consequences of human niche construction: examining long-term anthropogenic shaping of global species distributions, *Proceedings of the National Academy of Sciences U. S. A.*, 113 (23):6388. <https://doi.org/10.1073/pnas.1525200113>.
 8. **Bolund, P., and Hunhammar, S.** (1999). Ecosystem services in urban areas, *Ecological Economics*, 29(2):293–301. [https://doi.org/10.1016/s0921-8009\(99\)00013-0](https://doi.org/10.1016/s0921-8009(99)00013-0).
 9. **Boriea, M., Pelling, M., Ziervogel, G., and Hyams, K.** (2019): Mapping Narratives of Urban Resilience in the Global South, *Global Environmental Change*, 54:203-213. <https://doi.org/10.1016/j.gloenvcha.2019.01.001>.
 10. **Cameron, R.W.F., Brindley, P., Mears, M., McEwan, K., Ferguson, F., Sheffield, D., and Jorgensen, A. et al.** (2020): Where the Wild Things Are! Do Urban Green Spaces with Greater Avian Biodiversity Promote More Positive Emotions in Humans?, *Urban Ecosystems*, 23(2):301-317. <https://doi.org/10.1007/s11252-020-00929-z>.
 11. **Cardou, Françoise, Aubin, I., Lapointe, M., and Shipley, B.** (2022): Multifunctionality in Practice: Measuring Differences in Urban Woodland Ecosystem Properties via Functional Traits, *Urban Forestry & Urban Greening*, 68:127453. <https://doi.org/10.1016/j.ufug.2021.127453>.
 12. **Dasgupta, R., Basu, M., Hashimoto, S., Estoque, R.C., Kumar, P., Johnson, B.A., Mitra, B.K., and Mitra, P.** (2022):Residents' Place Attachment to Urban Green Spaces in Greater Tokyo Region: An Empirical Assessment of Dimensionality and Influencing Socio-Demographic Factors, *Urban Forestry & Urban Greening*, 67:127438. <https://doi.org/10.1016/j.ufug.2021.127438>.
 13. **Delhi Parks & Garden Society.** [online]. Available from: https://dpgs.delhigovt.nic.in/home/Delhi_Parks [Accessed 15 February 2022].
 14. Demographic profile of Delhi. [online]. Available from: delhiplanning.nic.in/sites/default/files/2%29%20Demographic%20Profile.pdf [Accessed 7 October, 2021]
 15. **Farahani, M., Leila, and Cecily Jane Maller, C.J.** (2018):Perceptions and Preferences of Urban Greenspaces: A Literature Review and Framework for Policy and Practice, *Landscape Online*, 61:1-22. <https://doi.org/10.3097/lo.201861>.
 16. **Gandherva, D., Bhattacharya, R., and Bhattacharya, P.** (2019):Assessment of User's Perception towards Urban Green Spaces: A Case Study of Delhi, India, *Journal of Ecology & Natural Resources*, 3 (1). <https://doi.org/10.23880/jenr-16000156>.
 17. **Green, O. O., Garmestani, A.S., Albro, S., Ban, N.C., Berland, A., Burkman, C.E., and Gardiner, M.M., et al.** (2015):Adaptive Governance to Promote Ecosystem Services In Urban Green Spaces, *Urban Ecosystems*, 19(1):77-93. <https://doi.org/10.1007/s11252-015-0476-2>.
 18. **Hadavi, S., Kaplan, R., and Hunter, M. C. R.** (2015): Environmental Affordances: A Practical Approach for Design of Nearby Outdoor Settings in Urban Residential Areas, *Landscape and Urban Planning*, 134:19–32. <https://doi.org/10.1016/j.landurbplan.2014.10.001>.
 19. **Haq, S. M.** (2011):Urban Green Spaces and an Integrative Approach to Sustainable Environment, *Journal of Environmental Protection*, 2(5):601–8. <https://doi.org/10.4236/jep.2011.25069>.
 20. **IMD-Indian Meteorological Department,** [online]. Available from: <https://city.imd.gov.in/citywx/extreme/OCT/safdarjung2.htm> [Accessed 02 October, 2021].
 21. **James, P., Hart, J.E., Banay, R.F., and Laden, F.** (2016):Exposure to Greenness and Mortality in a Nationwide Prospective Cohort Study of Women, *Environmental Health Perspectives*, 124(9):1344–52. <https://doi.org/10.1289/ehp.1510363>.
 22. **Lahoti, S., Lahoti, A., Joshi, R.K., and Saito, O.** (2020):Vegetation Structure, Species Composition, and Carbon Sink Potential of Urban Green Spaces in Nagpur City, India, *Land*, 9(4):107. <https://doi.org/10.3390/land9040107>.
 23. **Lee, A. C. K., and Maheswaran, R.** (2010):The Health Benefits of Urban Green Spaces: A Review of the Evidence, *Journal of Public Health*, 33(2): 212–22. <https://doi.org/10.1093/pubmed/fdq068>.
 24. **MacKerron, G., and Mourato, S.** (2013):Happiness Is Greater in Natural Environments, *Global Environmental Change*, 23(5):992–1000. <https://doi.org/10.1016/j.gloenvcha.2013.03.010>

25. **Moss, J. L., Doick, K.J., Smith, S., and Shahrestani, M.** (2019):Influence of Evaporative Cooling by Urban Forests on Cooling Demand in Cities, *Urban Forestry & Urban Greening* 37: 65–73. <https://doi.org/10.1016/j.ufug.2018.07.023>.
26. **Pace, R., Fino, F.D., Rahman, M.A., Pauleit, S., Nowak, D.J., and Grote, R.** (2020):A Single Tree Model to Consistently Simulate Cooling, Shading, and Pollution Uptake of Urban Trees, *International Journal of Biometeorology*, 65(2):277–89. <https://doi.org/10.1007/s00484-020-02030-8>.
27. **Rahman, M.A., Stratopoulos, L.M.F., Moser-Reischl, A., Zölch, T., Häberle, K.H., Rötzer, T., Pretzsch, H., and Pauleit, S.** (2020):Traits of Trees for Cooling Urban Heat Islands: A Meta-Analysis, *Building and Environment*, 170 (March): 106606. <https://doi.org/10.1016/j.buildenv.2019.106606>.
28. **Rigolon, A., Browning, M., Lee, K., and Shin, S.** (2018):Access to Urban Green Space in Cities of the Global South: A Systematic Literature Review, *Urban Science*, 2(3):67. <https://doi.org/10.3390/urbansci2030067>.
29. **Ruiz-Luna, A., Bautista, R.B., Hernández-Guzmán, R., and Camacho-Valdez, V.** (2019): Uneven distribution of urban green spaces in a coastal city in northwest Mexico, *Local Environment*, 24(5):458-472. <https://doi.org/10.1080/13549839.2019.1590324>.
30. **Schipperijn, J; Ekholm, O.; Stigsdotter, U.K.; Toftager, M; Bentsen, P; Kamper-Jørgensen, F. & Randrup, T. B.** (2010):Factors Influencing the Use of Green Space: Results from a Danish National Representative Survey, *Landscape and Urban Planning*, 95(3): 130–37. <https://doi.org/10.1016/j.landurbplan.2009.12.010>.
31. **Semeraro, T., Scarano, A., Buccolieri, R., Santino, A., and Aarveaara. E.** (2021): Planning of Urban Green Spaces: An Ecological Perspective on Human Benefits, *Land*, 10(2):105. <https://doi.org/10.3390/land10020105>.
32. **Shao, Y., and Liu, B.** (2017): Place Attachment Assessment System in Contemporary Urbanism.” *Procedia Engineering*, 198:152–68. <https://doi.org/10.1016/j.proeng.2017.07.079>.
33. **Sharma, V., and Chaudhry, S.** (2018):Vegetation composition and plant diversity in mining disturbed tropical thorn forest of Asola-Bhatti Wildlife Sanctuary, Northern India. *Taiwania*, 63:267-280. <https://doi.org/10.6165/tai.2018.63.267>
34. **Shukla, A.K., Basu, A., and Singh, N.** (2014):Flora and Fauna of Delhi Ridge. In: Sinha, G.N. (Ed.), *An Introduction to the Delhi Ridge*. Department of Forests and Wildlife, Govt. of NCT of Delhi, New Delhi, 97-104. https://www.academia.edu/7367070/An_Introduction_to_the_Delhi_Ridge.
35. **Song, C., Ikei, H., Igarashi, M., Miwa, M., Takagaki, M., and Miyazaki, Y.** (2014):Physiological and Psychological Responses of Young Males during Spring-Time Walks in Urban Parks.” *Journal of Physiological Anthropology*, 33(1):8. <https://doi.org/10.1186/1880-6805-33-8>.
36. **Southon, G.E., Jorgensen, A., Dunnett, N., Hoyle, H., and Evans, K.L.** (2017): Biodiverse Perennial Meadows Have Aesthetic Value and Increase Residents' Perceptions of Site Quality in Urban Green-Space, *Landscape and Urban Planning*, 158(February):105–18. <https://doi.org/10.1016/j.landurbplan.2016.08.003>.
37. **Talukdar, S., Tripathi, S.N., Lalchandani, V., Rupakheti, M., Bhowmik, H.S., Shukla, A.K., Murari, V., et al.** (2021): Air Pollution in New Delhi during Late Winter: An Overview of a Group of Campaign Studies Focusing on Composition and Sources, *Atmosphere*, 12(11):1432. <https://doi.org/10.3390/atmos12111432>.
38. **Tan, X., and Shibata, S.** (2022):Factors Influencing Street Tree Health in Constrained Planting Spaces: Evidence from Kyoto City, Japan, *Urban Forestry & Urban Greening*, 67(January):127416. <https://doi.org/10.1016/j.ufug.2021.127416>.
39. **UN World Cities Report 2020: The Value of Sustainable Urbanization.** n.d. United Nations Human Settlements Programme (UN-Habitat), Nairobi, Kenya [online]. <https://unhabitat.org/World%20Cities%20Report%202020> [Accessed on 25 October 2021].
40. **United Nations, Department of Economic and Social Affairs, Population Division** (2019):World Urbanization Prospects 2018: Highlights (ST/ESA/SER.A/421). [online]. <https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html> [Accessed on 25 November 2021].
41. **Van Riper, C. J., Yoon, J.I., Kyle, G. T., Wallen, K. E., Landon, A. C., and Raymond, C.** (2019):The Antecedents of Place Attachment in the Context of an Australian National Park.” *Journal of Environmental Psychology*, 61:1–9. <https://doi.org/10.1016/j.jenvp.2018.11.001>

-
42. **Wang, P., Zhou, B., Han, L., and Mei, R.** (2021): The Motivation and Factors Influencing Visits to Small Urban Parks in Shanghai, China, *Urban Forestry & Urban Greening*, 60 (5): 127086. <https://doi.org/10.1016/j.ufug.2021.127086>.
43. **WHO Regional Office for Europe** (2017) Urban green space interventions and health: a review of impacts and effectiveness. Copenhagen: WHO Regional Office for Europe. [online].
- (http://www.euro.who.int/__data/assets/pdf_file/0010/337690/FULL-REPORT-forLLP.pdf?ua=1) [Accessed on 15 October 2021].
44. **Zhang, Y., Dijk, T.V., Tang, J., and Berg, A.** (2015): Green Space Attachment and Health: A Comparative Study in Two Urban Neighborhoods, *International Journal of Environmental Research and Public Health*, 12(11):14342–63. <https://doi.org/10.3390/ijerph121114342>.