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A Study the Ecosystem Services (ES) of Industries and Urban Green Spaces

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Abstract - This research was done to better understand the supply and demand for important ecosystem services, with a particular emphasis on the supplying, controlling, or cultural ecosystem services (ES) that the people of Nagpur City, a quickly developing urban center in Central India, utilize. In order to create a thematic map based on people's perceptions of demand and supply gaps in access to public urban green spaces (UGS), the study investigated participative tools. The participatory survey's goal was to learn about people's needs, the public UGS's accessibility and availability, & essential ES they were using. Urban planners & policy makers can use this information to gain a general understanding of Nagpur's green space availability & distribution. An inventive tool that has proven successful for documenting qualitative status, examining spatial distribution, and ranking UGS offerings is participatory mapping methodology. Incorporating participatory methods into geographic data can expand the advantages of UGS offerings. With the purpose of guaranteeing future urban sustainability through suitable & planned green infrastructure, these instruments aid in improved UGS governance.

Keywords - Urban Green Spaces, Ecosystem, Industries, Cultural, Nagpur

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INTRODUCTION

In an urban setting, places with grass, trees, or any vegetation are called Urban Green Spaces, whereas any visible bodies of water are called Blue Spaces. For sprawling cities, these are crucial measures of living conditions. Since Nagpur is located in the country's high temperature region, it is particularly important for the city to have public green & blue spaces as a public asset in order to lessen the negative effects of climatic unpredictability and susceptibility. Actually, making sure the flow of socio-cultural, economic, and ecological services is sustainable is one criterion for building resilient cities. This includes making sure there are enough of green spaces & open areas. There is a belief that investing in urban areas can help mitigate the effects of environmental change by developing biodiversity hotspots that are strategically planned. In order to make cities resilient, adaptation abilities will be vital. Urban green spaces (UGS) are now used throughout the text to describe both green and blue areas, and this is where the term originates. This study aimed to gain a better understanding of the demand-supply imbalance and notable ecosystem services in Nagpur city, a fast-growing metropolis in central India. Specifically, it focused on the provisioning, regulatory, & cultural ecosystem services (ES) that the inhabitants of this city utilize. Finding out what people need, how easily they can get their hands on public UGS, and which ES are most important to them was the goal of the poll that encouraged participation. In order to get a feel for the distribution & availability of green areas in Nagpur, this data is useful for policymakers and urban planners. In order to record qualitative status, analyze spatial distribution, and prioritize UGS provisions, participatory mapping methodology has proven to be an effective and unique strategy. More people can reap the benefits of UGS provisions when participatory approaches are integrated with spatial data. In order to guarantee future urban sustainability through planned green infrastructure, these techniques aid in improved UGS governance.

METHODOLOGY

The purpose of the participation survey was to learn how people in each of the city's 136 wards felt about the city's parks, blue spaces, and ecosystems by asking them a variety of questions. Between February and March of 2020, a total of 1050 people from 100 different wards were interviewed (Figure 1). The survey was meticulously designed & executed at various locations within each ward. The city-wide lockdown caused by the unexpected COVID-19 pandemic prevented the questioning of 39 wards (Figure 2). Prior to finalizing the questions, a semi-structured questionnaire was created and piloted. Better outreach & understanding were achieved by the translation of questions into the local tongue as

well. We prevented bias in the survey by selecting respondents at random. A total of 18 questions were posed, with 10 of them specifically pertaining to the city's publicly accessible green and blue spaces and how people perceive, use, and interact with them. They were asked eight basic questions to get a feel for their age, income, & background. To gain a better grasp of the local perspectives, we conducted in-person interviews and exchanges (Figure 3). The purpose of this survey was to learn more about urban blue green spaces in Nagpur by asking ten specific questions about their availability, accessibility, ecosystem service flow, & management concerns. Geographic information system (GIS) tools (Arc GIS) were utilized to create pertinent theme maps following data analysis of participation survey results.

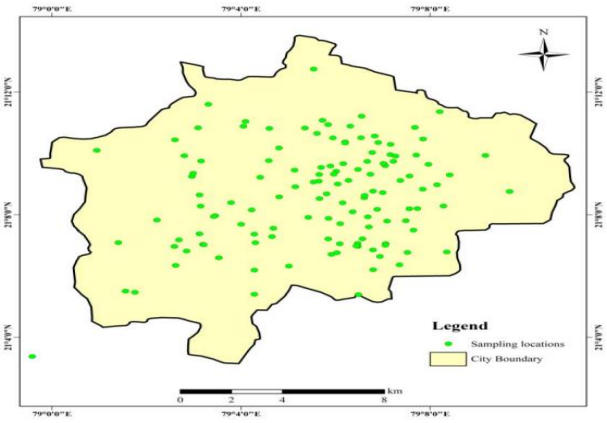

Figure 1: Locations of surveys in 100 wards of Nagpur for participatory evaluation

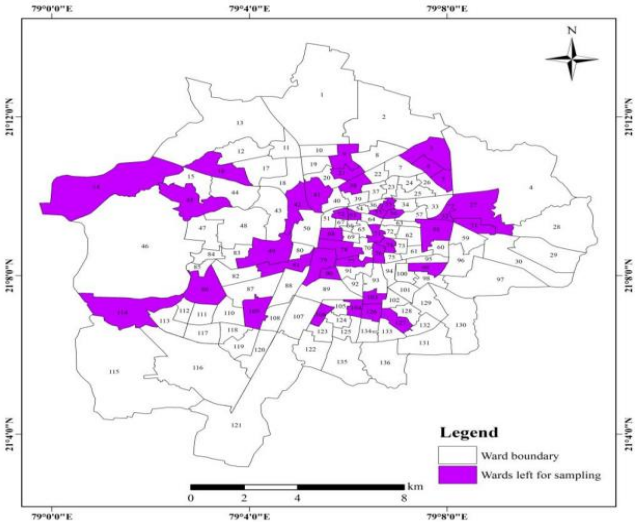

Figure 2: Nagpur map presentation 39 wards not assessed due to epidemic.

Figure 3: Survey of participatory ecosystem services (PES) in several Nagpur wards

RESULTS AND DISCUSSION

The accessibility, availability, & location-based recognition of public parks In order to gain a better knowledge of people' perspectives on urban green spaces, demand-supply gaps, ecosystem services, & management challenges, we offer the results of the participatory survey.

Summary of significant participants

In order to have a better grasp of our key respondents' backgrounds, we inquired about their age, sex, educational history, employment position, and income. These factors are known to impact their interests & responses. Of those who took part in the study, 65% were men and 35% were women. We further divided the respondents into four age groups, with 15 years old serving as the minimum age requirement for this study. The age groups of 31–50 years old accounted for 35.2% of the total responses, followed by 15–30 years old at 33.6%, 51–65 years old at 26.3%, and those older than 65 years old at 4.9%. Nearly 40% of the people who took the survey had completed some sort of postsecondary degree program; 27.2 percent had only completed high school; 15.5 percent were working toward a master's degree; 3.5 percent held a PhD; and 15.0 percent had some other type of less formal education. There were 47% in the workforce, 5.4% out of work, 22.5% in school, 16% retired from a variety of occupations, and 8.8% who helped out around the house for housewives. 43% made ten

lakh. In order to have a better understanding of the demand gap scenario in Nagpur city, we offered respondents yes/no questions about accessibility to UGS, and then we followed up with questions about distance travelled & frequency of visits.

Ecosystem Access in Urban Areas

We classified public urban green spaces as either "green" (parks, playgrounds, etc.) or "blue" (water fronts, ponds, lakes, wetlands), based on the fact that both types of spaces are vital ecosystems that supply numerous ES to the city dwellers of Nagpur, which is experiencing rapid urbanization. Figure 4 shows that while a small percentage of respondents (7.5%) preferred blue areas over green spaces, a large majority (93%) felt more at ease accessing green spaces. Parks are less congested than urban lakes and ponds, which could explain why people prefer them in hot weather.

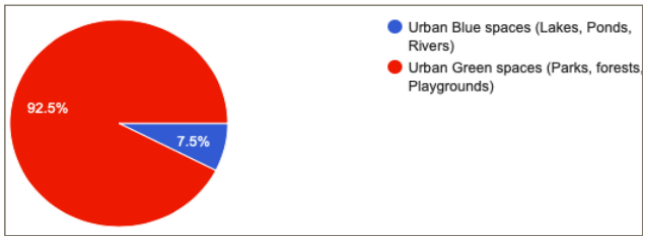

Figure 4: Exploring the accessibility of Nagpur's urban green & blue spaces

Disparity between the demand for and supply of enough green space

Responses varied across the rapidly developing city of Nagpur. In Figure 5, nearly half of the respondents agreed that there was enough greenery in their wards or neighborhood. On the other hand, nearly the same number of respondents were unsatisfied or gave a neutral or negative reaction. Because of our lack of familiarity with urban green needs, we interpreted a neutral response as such. Regardless of how easy it was for them to get to, 11% of respondents were very much in agreement, and 40% said there was enough greenery around. Some examples of such places include zudpi jungles, miniature urban forests, avenue plantings, and campus greenery. In contrast, 27.6% were ambivalent, 19.5% disagreed, and, shockingly, only 2.3% strongly disagreed.

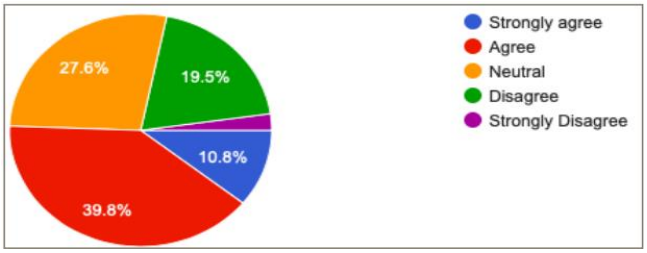

Figure 5: Disparities in ward greenery supply

UGS distance accessibility

We made an effort to comprehend the availability of urban green spaces for various wards. In order to reach public urban green spaces, 42.6% of respondents said they had to walk more than 500 meters. When you realize that these are the thoughts of many people, you can see that this is a considerable distance. Figure 6 shows that only 9% of people have convenient access near their homes, while 28% travel 200-500 m and 20.5% travel 50-200 m. Some of the main reasons why local residents have a harder time accessing UGS include dense infrastructure & population density.

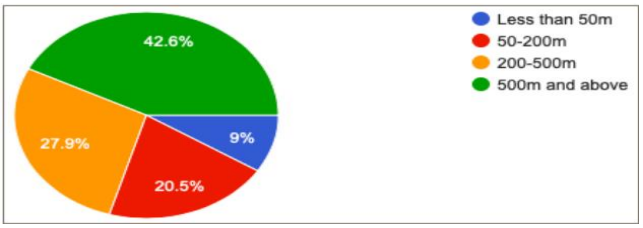

Figure 6: Urban green space benefit access distance

UGS visit frequency

Respondents showed a great deal of enthusiasm for making use of the city's UGS. In terms of frequency, over 44% of respondents were making frequent visits to the green areas, while 35% made one or two visits per week, depending on availability and schedule. More frequent visits are observed when green space is nearby. About 15% went at least once a month, whereas 7% either didn't have the time or didn't live near a park, garden, or lake where they could take advantage of it (Figure 7). Looking at the responses closely, it's evident that even while just around half of the population has daily access to these green spaces, there is still a significant portion of the population that doesn't get the chance to enjoy all the benefits that these areas have to offer.

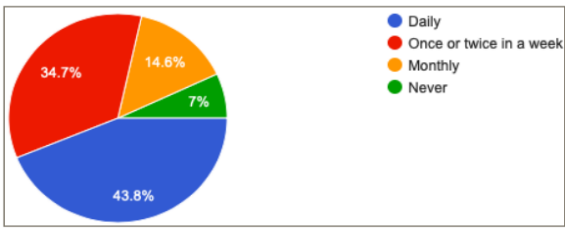

Figure 7: Accessibility in Nagpur as measured by the number of visits to public UGS

Public UGS management

During the questionnaire survey while, understanding accessibility to UGS we also tried to assess the level of satisfaction with the management of the public UGS in each ward. The interest of inhabitants in visiting managed green spaces is likewise determined by these sites. On occasion, residents travel farther to utilize UGS in far managed

green places due to unmanaged green spaces as well. Managing the green spaces was only a success for 7% of responders. In total, 43% were satisfied, which is close to 50%. In contrast, 21% were agnostic, 25% were unhappy, and 4% were extremely unhappy with this response. It is evident that the management of green spaces also played a role in guiding accessibility, and it is also evident that half of the city's residents were content with the way UGS were managed & cared for, while the other half were not.

Comparing green cover with location grading (map)

Figure 9 shows the wards coded according to inhabitants' own responses: red, orange, and green.

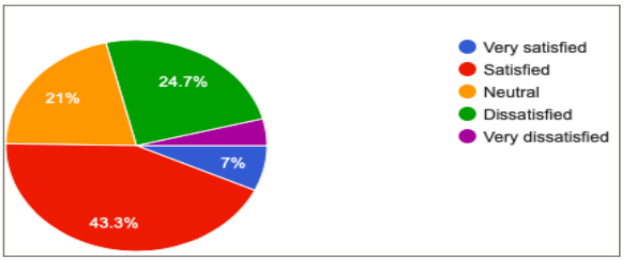

Figure 8: Urban green and blue space management in Nagpur

In terms of amenities, accessibility, availability, and management, the green-colored areas on the map indicate wards where the majority of respondents were satisfied with the public UGS. If nothing is done, the orange wards could end up in the city's red zones; on the other hand, if we move quickly but carefully, there's a possibility that they could end up back in the green zones in five years. Without a doubt, every red ward, no matter its size, population, or location, was in a perilous situation. There are a number of central wards that appear white but are actually crimson because of their cramped design, high population density, and inability to accommodate plantations. We will have a better idea of the situation after we have polled every ward in the city with the identical questions after the lockdown. Feedback provides a clear picture: half of the wards are green and have sufficient access and availability, but another forty-four wards close to fifty require assistance in preserving existing patches of green space and reclaiming more land to ensure that these areas too have enough of green space.

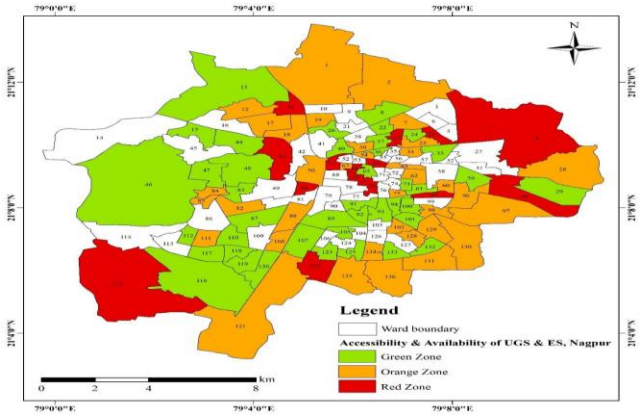

Figure 9: Nagpur map with color gradations based on local responses for green space place-based identification (white-colored wards could not be surveyed).

In order to provide a clearer picture of the individual wards, excluding Figure 9. To help identify which areas in the orange and red zones needed additional focus, we created Table 1. In addition, it should be noted that the current green spaces (Table 1) require protection and management in order to prevent encroachment and felling.

Table 1: Green, orange, and red zones based on availability, access, and management of green spaces in Nagpur wards and local neighborhoods

Sr. No.	Green Zone	Orange Zone	Red Zone
1	Ajni (107)	Ayodhya Nagar (134)	Bhaldarpura (69)
2	Ambazari (46)	Babulban (60)	Bhandewadi (30)
3	Ashirwad Nagar (132)	Balabhaupeth (39)	Boriyapura (51)
4	Juna Bagadganj (61)	Barse Nagar (54)	Dhammadeep Nagar (26)
5	Bhagwan Nagar	Besa	Hansapuri (66)
6	Binaki (24)	Chhaoni (18)	Hiwari Nagar
7	Chandan Nagar	Chitnavispura (75)	Jogi Nagar (122)
8	Chandramani Nagar (105)	Chunabhatti (108)	Kalamna (4)
9	Chatrapati	Dighori (130)	Lakadganj
10	Civil lines (48)	Ganesh Nagar	Mahal (70)
11	Dhantoli	Gopal Nagar (111)	Mankapur (11)
12	Dharampeth (83)	Hasanbagh (98)	Maskasath (64)
13	Dnyaneshwar Nagar (125)	Hilltop (85)	Near ayachit mandir
14	Dikshabhoomi (87)	Khalasi line (50)	Om Nagar
15	Gandhi Bagh (65)	Jafar Nagar (12)	Panchsheel Nagar (23)
16	Gorewada (13)	Jail ward (88)	Rajendra Nagar (95)
17	Hanuman Nagar (92)	Jaitala	Sadar (43)
18	Indora (20)	Janki Nagar (136)	Shivangaon (115)
19	Jaiprakash Nagar (119)	Jaripatka (19)	Sitabuldi (80)
20	Juni Mangalwari (73)	Mahendra Nagar (7)	
21	Juni Shukrawari (94)	Manewada (135)	

22	Kawarapeth (33)	Mehandibagh (25)	
23	Lashkaribagh (40)	Mahalgi Nagar (131)	
24	Laxmi Nagar	Mominpura (67)	
25	Medical (89)	Nagsen ngar	
26	Nalanda Nagar (8)	Nara (1)	
27	Nandanvan (100)	Narendra Nagar (121)	
28	Nehru Nagar (101)	Nari (2)	
29	New Subedar Layout (133)	Padole Nagar (96)	
30	Pardi (29)	Parvati Nagar	
31	Prashant Nagar	Police line takli (17)	
32	Pratap Nagar (110)	Prem Nagar (34)	
33	Ramdaspeth	Punapur (28)	
34	Rameshwari (123)	Queta colony (62)	
35	Ravi Nagar	Ram Nagar (84)	
36	Reshimbagh (93)	Ramna maroti (129)	
37	Seminary hills (44)	Sakkardara (102)	
38	Shivaji Nagar	Satranjipura (63)	
39	Siddharth Nagar (22)	Shankar Nagar (82)	
40	Siraspeth (91)	somwaripeth	
41	Somalwada (120)	Tajbagh (128)	
42	Sonegaon (116)	Vathoda (97)	
43	Subhash Nagar (112)	Vishwakarma Nagar	
44	Swavalambi Nagar (117)	Yashodhara Nagar	
45	Tandapeth (36)		
46	Telangkhedi (47)		
47	Friends colony (15)		
48	Vaishali Nagar (37)		
49	Wardhaman Nagar (59)		
50	Khamla (118)		

Better green infrastructure design in Nagpur city is possible because to the improved information derived from participative and geographical data. Various wards of Nagpur have various documented statuses of public urban green & blue areas, indicating a demand-supply discrepancy. The abundance of natural green spaces in the western section of the city more than makes up for the absence of UGS facilities in the eastern part.

Ecology Services Evaluation with Public Involvement

People are getting involved in sharing information about ecosystem services (ES) to help with informed management, which is great because more and more people are realizing how important ES are. To meet the current and future needs of rapidly growing cities like Nagpur, it is important to use local knowledge and identify strategic management approaches while designing environmentally friendly infrastructure. Locals reap social, economic, cultural, and health benefits from ecosystem services (ES). Rapid land management decisions frequently fail to include these intricate and location-specific ES because they are evaluated using generalized, top-down methods. A new method for quick evaluation of local ES provision employing inductive, participatory approaches has been investigated, and it is based on place-based participatory Ecosystem Service (ES). More personal opinion and background was uncovered via free-listed responses. This work is a great example of how local people's views on environmental sustainability (ES) can be included in future plans for urban green spaces, and it shows how important it is to thoroughly analyze ES provision in order to fully inform conservation and planning at the local level, which benefits both communities and nature. Urban green spaces offer a variety of ecosystem services (ES), including provisioning, regulation, and cultural ES, which we explored in our inquiries. Below is a thorough overview of the responses:

Offering Services to Ecosystems

In addition to providing raw materials, fresh water, food, & medicinal resources, UGS offers a wide range of provisioning services. Urban foraging for food, medicine, fuelwood, and fodder is an essential provisioning function provided by current UGS in Nagpur, although it has just been explored in this survey. While it's true that UGS don't really offer any provisioning services, they were a lifeline for people in India, where many people still choose to eat wild edibles rather than store-bought food (either because they're healthier or because they don't have the money to buy it). Insight into the provision of UGS perks was shared by our respondents. Women in the middle age bracket often collected tiny amounts of various plants for religious and culinary purposes, as well as food and medicine (Figure 10). These plants included kadi patta, tulsi, moringa, neem, sesbania, and many more. The urban poor often have to rely on foraging for food and other necessities because they don't have access to other sources. The zudpi jungle and avenue trees offer a variety of wild flowers, fruits, and other items that the poor slum dwellers can use for themselves or sell at local markets. Among the UGS surveyed, 20.5% said they used them for food, nutrition, or therapeutic purposes; this number does not exclude parks and gardens run by NMC or NIT. A tiny percentage of people (1.2%) said they occasionally collected leaves to feed to their animals, such as goats. 2% of slum dwellers also gathered deadwood for fuelwood, and 38% said they had other supplies, such as medicinal herbs, for certain one-time, non-recurring needs. Figure 11 shows that a significant portion of the respondents, 77.5% to be exact, were not directly involved in gathering UGS data.

Figure 10: Provisioning services & urban foraging are both supported by UGS in Nagpur.

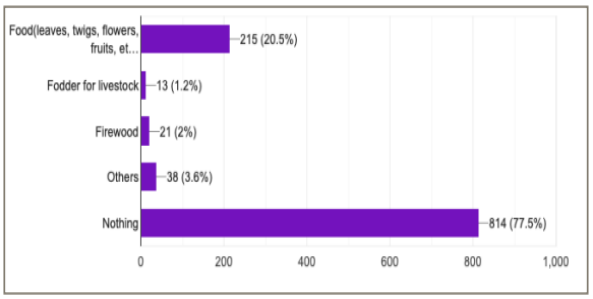

Figure 11: The provisioning (direct use values) advantages of parks and other urban green areas

Ecosystem Service Regulation

Some key regulatory ES from urban ecosystems include air and climate improvement, carbon sequestration & storage, extreme event mitigation, and wastewater treatment. We conducted this survey to determine whether or not UGS was enough in Nagpur for mitigating heat islands and air pollution. We polled city dwellers to find out if they thought the city's public parks were enough to combat air pollution & heat island effect, in which the middle of the city is hotter than the outside. Heat islands needed a more contextual explanation, so we connected them to hotter markets and urban regions rather than green zones. UGS are enough to absorb air pollution and reduce heat islands, according to 29.6% of respondents, while 5.4% strongly agreed. Existing green areas are sufficient in mitigating air pollution and reducing heat islands; nevertheless, 30.4% of respondents were agnostic, meaning they did not agree or disagree. Not everyone agrees that current UGS are enough; in fact, 30.3% of people disagreed and 4.3% strongly disagreed. Figure 12 shows the area graded in green, orange, and red. This helps to explain the variances in reactions.

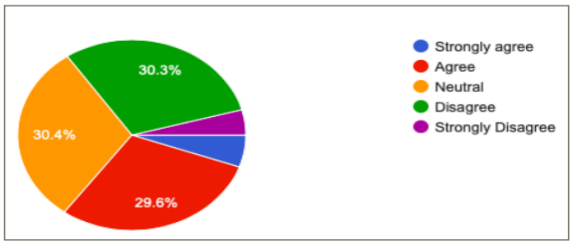

Figure 12: Nagpur's urban gas scrubbing system (UGS) to mitigate air pollution and heat island impacts

Ecosystem Services in Culture

Among the many ecological services provided by urban and other green areas are cultural ones, such as opportunities for rest, reflection, and connection to one's community. Among the most noticeable cultural and recreational advantages of green & blue spaces are the health benefits they provide to city dwellers, who can take advantage of UGS for things like early or late-night walks, running, exercising, picnicking, socializing, yoga, meditation, and more. We refrained from viewing religious advantages of UGS as significant cultural endowments. Figure 7 shows that we also made an effort to comprehend the cultural ES by analyzing the frequency of visits to UGS. Figure 13 shows that about 44% of respondents were making daily visits to the UGS, 35% were doing so once or twice a week, 15% were making monthly visits, and 7% were not making any visits at all.

In response to our cultural service-focused inquiries, we learned that 58.5% of people use UGS for walks in the morning or evening, 48.5% for running & exercise, and 21.6% for yoga or meditation. It's nice to see that people associate UGS with health. These folks dropped around more or less regularly, maybe once a day or every other day. The majority of the 6.4% who visited UGS on a monthly or more often basis were regulars who used it for picnics and other leisure activities. Also, 33.4% went to UGS in the city to hang out with friends & enjoy the atmosphere (Figure 14). The replies that were shared were intriguing to observe, and they provided obvious proof that UGS possess significant cultural ES that must be safeguarded through the management, restoration, & protection of these areas.

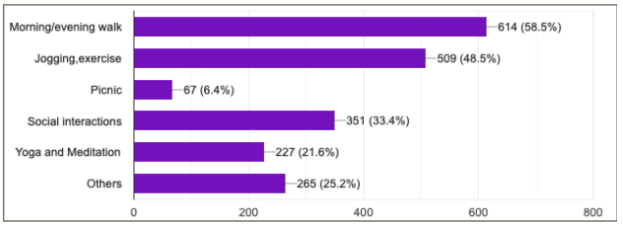

Figure 13: Utilization of Urban Green Spaces (UGS) in Nagpur's Cultural Ecosystem

Figure 14: UGS in Nagpur as significant spaces for cultural exchange and pleasure

In addition, we aimed to learn about the physical & mental advantages of UGS and nature in Nagpur through our survey questions. What is it about metropolitan settings that entices people to be near natural places? Of those who visited UGS, 82% wanted to enjoy the outdoors, 63.4% wanted to improve their health, and 33.2% wanted to find some tranquility and relief from stress. Figure 15 shows that 22.1% of people reported experiencing positive emotions & enjoying themselves when viewing butterflies and birds. Ward residents in the areas marked red and orange in Figure 9 and Table 1 do not have access to these regular and essential

benefits, which also gave them a sense of belonging and attachment to UGS.

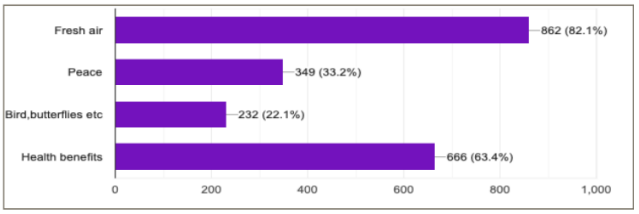

Figure 15: Possibilities for attachment and nature connection

CONCLUSION

The requirements for UGS can differ from one nation to another. Twenty square meters of green space, or "minimum of 1.25 ha open space per 1,000 residents," is recommended by the best practices in per capita provisioning. When deciding what kinds of facilities are necessary, local governments go to the 2014 National Housing and Urban Affairs Ministry's URDPFI guidelines. Overdensification has led to the city of Nagpur rapidly expanding & urban sprawl issue worsening. Our participatory poll found that the city's already-stressed public UGS are rapidly deteriorating. For development to be both effective & sustainable, they need to be involved in the planning of Green Infrastructure (GI). The absence of local level data in conservative statistically based land-use planning could impede long-term planning, provision, and conservation efforts related to UGS. Additionally, the study highlights the significance of UGS in urban areas for managing health advantages and psychological benefits, which in turn enhance people's resilience over time. With the use of the green, orange, & red codes, city planners may better allocate resources to enhance UGS in each ward.

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