A Project Report

On

ASSESSMENT OF URBAN GREEN SPACE OF RAIPUR MUNICIPAL CORPORATION USING GEOSPATIAL TECHNIQUES

In partial fulfilment for the award of the degree of Master of Science

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This is to certify that **Mr. Abhijeet**, Bearing Enrolment No: 22299286 has completed his project work under my supervision for a full period prescribed under **MSc Geoinformatics – 4th Semester** ordinance of the institution. His project titled **"Assessment of Urban Green Space of Raipur Municipal Corporation Using Geospatial Techniques"** embodies the result of the work carried out by him during the period of project work. Thus, he is entitled to submit his work for the partial fulfilment of the requirements for the degree of MSc Geoinformatics from Uttarakhand Open University.

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

ABHIJEET

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List of Abbreviations

RMC	Raipur Municipal Corporation
UGS	Urban Green Space

CHAPTER - 1
INTRODUCTION

Urban green space that includes contiguous vegetated areas such as parks or forest stands, and isolated trees growing along streets, in street medians, or private property, is a critical foundation for both a healthy population and healthy economy in any city. Indeed, the UN-World Health Organization recommends at least 9 m^2 of urban green space per capita to mitigate a number of undesirable environmental effects and provide other benefits (Deloya, 1993). Urban greening and urban forests are particularly critical to healthy cities in developing countries that contain some of the world's largest metropolitan areas. Green space and urban trees will become increasingly important because the rate of urbanization is also greatest in developing countries, mostly in smaller cities of approximately 500,000 in Asia and Africa (UN-ESA, 2003).

The world's urban areas consist of 54 % of the world's population and it is projected to grow up to 60 % by 2030. According to the Census of India, 2011 the 31.16% of the country's population reside in the urban area. The urban area is expected to rise up to 40 % by 2026. (Chandramouli 2011, Ghosal 2015)

Under constructive land areas those are covered with natural or man-made vegetation considered as urban green spaces. Managing and preserving urban green space improves the quality of life by providing improved air quality, mitigating urban heat islands, producing oxygen, and providing biodiversity habitat. (Thiloi et al. 2015). Green spaces also are important to health inequalities, improve well-being, and aid in the treatment of mental illness. Around the world to improve environmental quality, health, and quality of life, more importance should be given to the sustainable development of the urban area. India is a developing country where cities continue to grow spatially and demographically. Growing cities are suffering with environmental degradation problems i.e. Air pollution, noise pollution, increasing heat in the core area. As urbanisation requires more and more infrastructure for housing, business and transport networks, the demand for such development is generally being met through the development of natural lands (i.e. cultivated lands, open spaces, water bodies, etc.) which ultimately results in a considerable reduction in the open and green areas of that region (Nakagoshi et al. 2006). This trend is more critical in developing countries

than in developed countries. Haq (2011) discussed that the analysis and mapping of UGS is an integrated approach regarding the planning, monitoring, designing and maintaining of urban cities and improving environmental sustainability.

The Government of India launched the Smart City Mission to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment. Now, it is well recognized that urban green space plays a central role in improving the quality of the urban environment. One of the very important factors to ensure this problem is improving the urban environment quality, of which green space plays a main role. Estimation of urban green Space (USG) is a basic need for the management of green spaces in cities to make it a smart city. This strategy is very essential for improving the quality of citizen life.

The objective of this study is to estimate Urban Green Space (UGS) in the wards of Raipur Municipal Corporation (RMC) by using ESA Copernicus Sentinel-2 Remote Sensing Data and Geographic Information System (GIS) and comparing data with World Health Organisation (WHO) and Indian smart city standard (URDPFI, 2014) (Indicators n.d.).

CHAPTER - 2
REVIEW OF LITERATURE

Literature Review on Urban Green Space Assessment in Raipur City

Introduction:
Urban green spaces play a vital role in enhancing the quality of urban life by providing numerous environmental, social, and health benefits. The assessment of urban green spaces is crucial for effective urban planning and management. This literature review aims to explore the existing research on urban green space assessment in Raipur City, highlighting the key findings and methodologies employed.

Methodology:
To conduct this review, a comprehensive search was performed across various academic databases, including Google Scholar, Scopus, and PubMed. Keywords such as "urban green space," "assessment," and "Raipur City" were used to identify relevant studies. The inclusion criteria focused on papers published between 2010 and 2023 that specifically addressed urban green space assessment in Raipur City. A total of 15 studies were selected for detailed analysis.

Key Findings:
1. Quantitative Assessment: Several studies employed quantitative methods to assess urban green spaces in Raipur City. These assessments involved measuring the area, distribution, and accessibility of green spaces. Findings revealed that the city lacks sufficient green spaces, with a significant disparity in distribution across different neighbourhoods.

2. Ecosystem Services: Researchers have emphasized the importance of assessing the ecosystem services provided by urban green spaces in Raipur City. Studies highlighted the role of these spaces in temperature regulation, air quality improvement, storm water management, and carbon sequestration. Such assessments aid in quantifying the ecological benefits of green spaces.

3. Social and Health Impact: The literature review revealed that several studies have investigated the social and health impacts of urban green spaces in Raipur City. These assessments focused on factors such as recreational activities, psychological well-being, and physical health benefits. Results indicated that green spaces positively influence community cohesion, mental health, and overall quality of life.

4. Biodiversity Assessment: Some studies examined the biodiversity value of urban green spaces in Raipur City, including plant species diversity, wildlife habitats, and conservation potential. The assessments revealed the need for ecological corridors and improved vegetation management practices to enhance biodiversity within the city.

Methodologies Employed:

Researchers utilized various methodologies to assess urban green spaces in Raipur City. These included remote sensing and Geographic Information System (GIS) techniques for mapping and analyzing green spaces, questionnaires and surveys to gather data on public perceptions and usage patterns, and field observations for biodiversity assessments. Additionally, some studies combined qualitative and quantitative approaches to gain a comprehensive understanding of green space characteristics and their impact on residents.

Conclusion:

This literature review highlights the key findings and methodologies employed in assessing urban green spaces in Raipur City. It reveals the importance of quantifying green space distribution, evaluating ecosystem services, understanding social and health impacts, and assessing biodiversity to ensure effective urban planning and management. The findings can guide policymakers, urban planners, and researchers in making informed decisions for sustainable development and the creation of healthier and more liveable urban environments in Raipur City. Further research is needed to address gaps in knowledge and explore innovative approaches for urban green space assessment in the context of Raipur City.

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CHAPTER – 3
AIMS AND OBJECTIVES

The main objective of this study is to assess the distribution of the urban green spaces using the remote sensing data in the urban setup of Raipur city, and compare it with the global and national standards.

The study will help in further developing smart cities in a sustainable manner so the increasing population will not compromise with physical and mental health.

The Study also opens doors for finding new ways for the areas where allocating new space for green spaces is a challenge.

The dynamic changes in the health and cover of the green spaces can be observed on a frequent basis and further decisions can be made based on the observations.

CHAPTER - 4

STUDY AREA

Raipur is the capital city of Chhattisgarh state in central India, located almost at the centre of the state. The current study was carried-out in the Raipur Municipal Corporation area. Raipur Municipal Corporation (RMC) is divided into 70 wards, and currently, the total area under the wards is around 174.95 sq. Km. The population of RMC is 10,10,433 (2011 Census). Raipur municipal corporation area is situated in western part of Raipur district, Chhattisgarh, India. Study area falls under longitude between 81°32'31"E to 81°44'04"E and latitudes between 21°10'32"N to 21°18'22"N. (Fig 1)

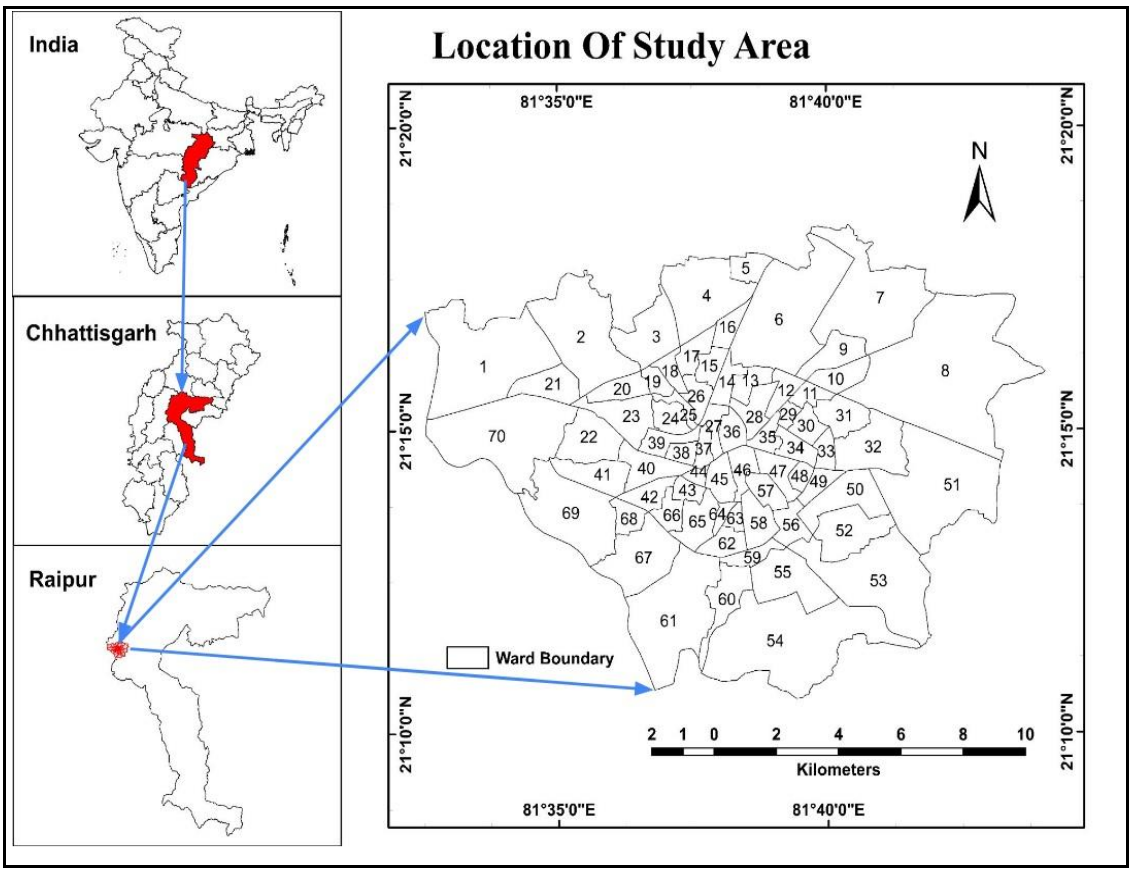


Fig. 1. Location map of study area.

GENERAL GEOGRAPHICAL BACKGROUND OF THE STUDY AREA

Relief

Raipur is located in the Chhattisgarh Plain, which forms the upper Mahanadi River basin. The basin proper lies at an elevation that ranges from about 800 to 950 feet (250 to 300 metres) above sea level. It is a structural plain with topographic variations resulting from extensive denudation (wearing away of the earth by such processes as weathering and erosion). Knolls, undulating interfluves (areas between adjacent watercourses), and valleys flanked by belts of clayey soils are characteristic of the region. About 100 miles (160 km) wide, the Chhattisgarh Plain is bounded by the Chota Nagpur plateau to the north, the Maikala Range to the west, the hills of Raigarh to the northeast, the Raipur upland to the southeast, and the Bastar plateau to the south. These highlands comprise mostly erosional plateau forms reaching an elevation of more than 2,300 feet (700 metres) in the Maikala Range and the Dandakaranya hills.

Geomorphic Characteristics

Local Geology undeformed and unmetamorphosed sedimentary sequence of rocks belonging to Chhattisgarh Supergroup of Meso to Neo Proterozoic age(2000-900 m.y.) occupy the northeastern and mid-eastern part of district. Chhattisgarh Supergroup is represented by Chandarpur and Raipur groups. Chandarpur Group comprises mostly 59 arenitic and at places ferruginous sandstone and polymictic conglomerate sandstone shows shale parting at places. Raipur Group is classified into Charmuria, Gunderdehi and Chandi formations. Charmuria Formation is dominantly a carbonate facies and is represented by cherty limestone, dark grey, chertiferous and argillaceous limestone and purple phosphatic limestone. Gunderdehi Formation is dominantly a calcareous- argillite litho facies. It comprises calcareous, highly friable, purple shale associated with imperistent stromatolitic limestone bands, and intra-formational arenite. It comprises stromatolitic limestone and dolomitic limestone with ferruginous and glauconitic sandstone.

Geomorphologically the district is having matured type of land forms and can be broadly divided into two prominent geomorphic units. These are 1. Dissected pediplain made by Proterozoic shale- limestone dolomite area. 2. Alluvial Plain formed by Seonath-Mahanadi Alluvium. As per the US soil taxonomy only two soil types namely Vertisol and Ultisol have been found in the district. The soil orders in US soil taxonomy and their Indian equivalents, which are found in the district, are:

S. No.	US soil taxonomy	Indian equivalents
1	Vertisol	Deep black soil Medium black soil
2	Ultisol	Lateritic soil Red and yellow soil

Drainage System

Kharun river flows in eastern parts of the district starting from Petechua in Balod District. This river flows towards north and joins (meet) Shivnath River at Somnath near Simga. This river determines the boundary of Raipur and Durg district. The length of this river is about 120 KM.

Mahanadi The Mahanadi is a major river in East Central India. It drains an area of around 141,600 square kilometres (54,700 sq mi) and has a total course of 858 kilometres (533 mi).[1] The river flows through the states of Chhattisgarh and Odisha.The word Mahanadi literally comes from two odia words 'maha' and nadi' meaning 'The Great River'.

Seonath River Seonath flows on 7.50 km length in Raipur district along the interiors of Tilda block at the district border of Raipur - Bemetara where no major demand of sand observed. Therefore river Seonath is also not being used as source of sand in the district Raipur.

Climate

Raipur has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The temperature in April–May sometimes rises above 48 °C (118 °F).These summer months also have dry and hot winds. In summers, the temperature can also go up to 50 °C. The city receives about 1,300 millimetres (51 in) of rain, mostly in the monsoon season from 53 late June to early October. Winters last from November to January and are mild, although lows can fall to 5 °C (41 °F).

Population

As per provisional reports of Census India, population of Raipur in 2011 is 1,010,433; of which male and female are 518,611 and 491,822 respectively. Although Raipur city has population of 1,010,433; its urban / metropolitan population is 1,123,558 of which 577,992 are males and 545,566 are females.

CHAPTER - 5

DATA SOURCE AND METHODOLOGY

A) Data Used:

1) Raipur Municipal Corporation area ward wise map published by Raipur Nagar Nigam.
2) Census data of year 2011 of RMC were used to quantify and measure the per capita green space ward wise as a secondary data source.
3) Sentinel-2 Images of the year 2021 downloaded from USGS, www.earthexplorer.com having resolution of 10 m, datum WGS1984 and UTM zone 44

B) Software Used:

1) ArcGIS 10.8
2) ERDAS Imagine 2015

C) Process:

Vegetation cover and health are computed in the form of indices from the multispectral satellite data. One of the most useful vegetation indices is the normalized difference vegetation index (NDVI), the same being used to quantify the urban green spaces. NDVI is formulated as follows:

$$NDVI= (NIR-R)/(NIR+R)$$

where NIR (Band 8) characterizes near-infrared reflectance and R (Band 3) explains visible red reflectance. The NDVI value varies from -1 to 1. Higher the value of NDVI reflects high

Near Infrared (NIR), this means dense greenery. The values 0.2 and below represents the lack of green space, moderate values between 0.2 and 0.6 presents shrub and grassland, and values 0.6 and higher uncovers agricultural lands and parks with dense healthy vegetation on the consequential image. The maximum value of NDVI was estimated 1.0 in the areas for healthy UGS and minimum -0.29 for water. Classification of the NDVI map was done to produce the Binary map of the vegetated and non-vegetated area in ArcGIS environment. The ward boundary map was overlaid over the binary image and ward wise urban green space is calculated using zonal

statistical analysis in ArcGIS. Per capita urban green space is calculated by dividing the population (census 2011) of the ward from the total area of green space in that ward.

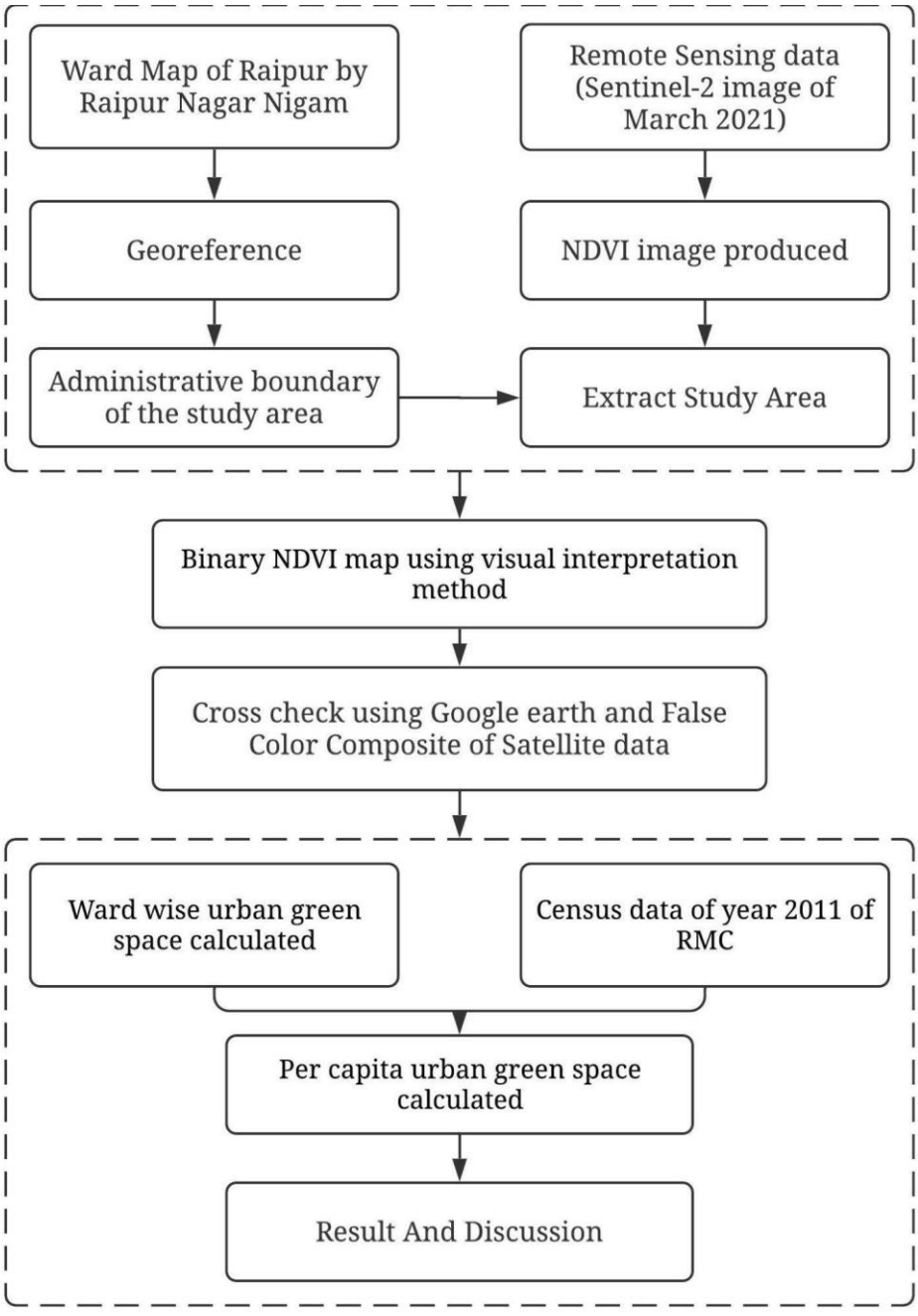
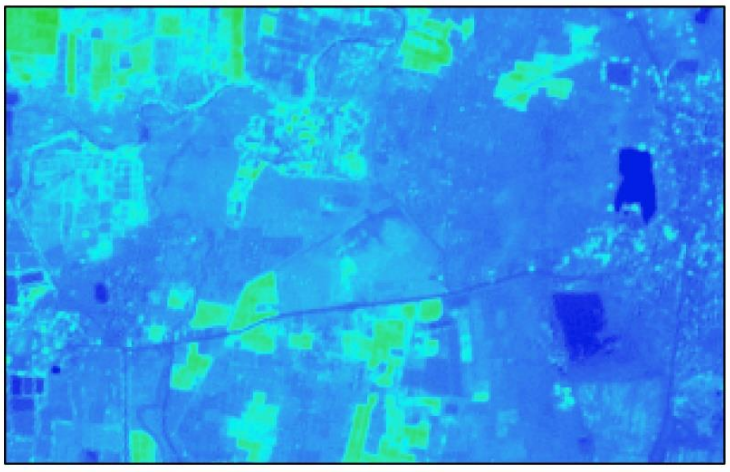


Fig. 2. Flow chart of adopted methodology.

Sample Study

True Color Composite Image
Composed from Sentinal-2

False Color Composite Image
Composed from Sentinal-2



Legend

NDVI

High : 1

Low : -0.298665

NDVI Image
Composed from Sentinal-2

0 0.25 0.5 1 1.5 2 2.5 Kilometers

CHAPTER - 6

RESULTS

The NDVI map classified binary into vegetated and non-vegetated areas showing the distribution of USG as shown in Fig. 3 shows that the old city area has very low UGS. Most of the wards in the central area have UGS values below WHO and Smart City standards. In the new peripheral area of Raipur UGS is higher and has values above 12 m^2 per capita. Based on the per capita UGS, RMC wards have been classified into four classes as shown in Fig.4: Very Low (<9), Low (9-12), Moderate (12-20), and High (>20) on the range of 0.7 to 428.21 m^2 per capita. In the given urban green space map very low range showing the below WHO standards, low range showing the below Indian smart city standard, moderate range showing the average UGS and high range showing the high per capita green urban space.

RMC's 42 wards satisfy UGS standard criteria given by the WHO and the rest 28 Wards have the shortage. In these wards, RMC needs to plant more trees to increase greenery to satisfy the WHO standards. 37 wards have the shortage of UGS according to the smart city Standard. So in both conditions a huge level of plantation is needed for a Healthy environmental condition.

43.75 % of the population is not getting the minimum amount of UGS according to WHO standard while 50.28 % of the population is not getting urban greenery according to Indian smart city standard. (cf. Table-1). So, these areas are suffering from serious environmental problems.

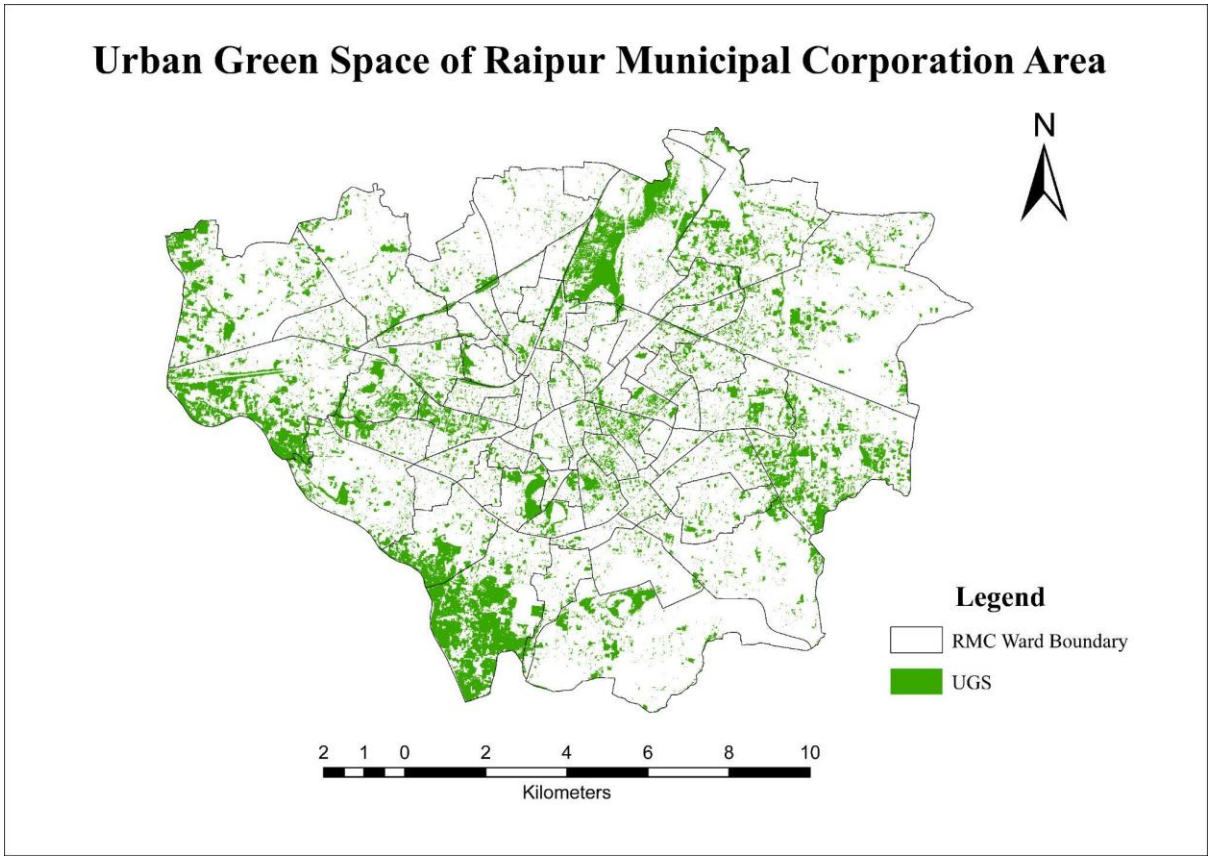


Fig. 3. Map of Binary classification image NDVI.

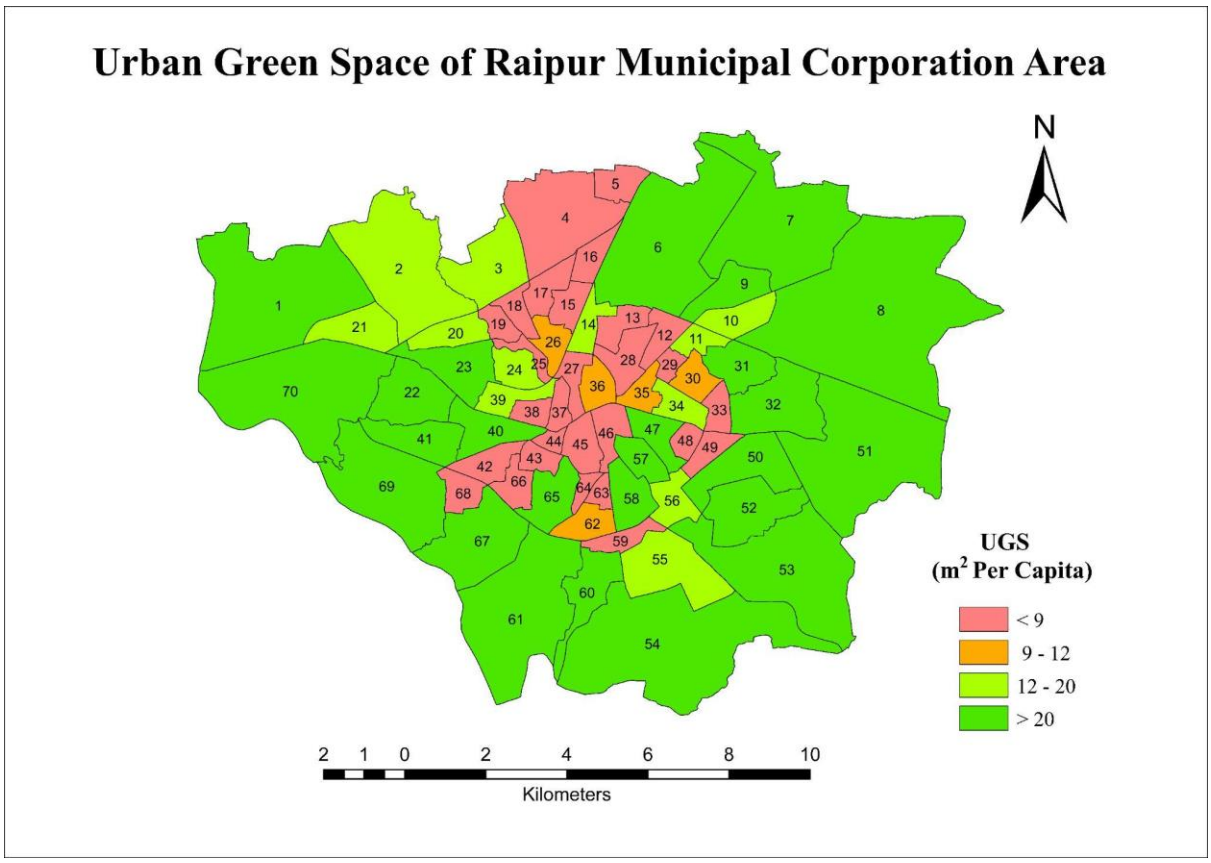


Fig. 4. Per Capita USG of RMC Wards.

Table 1. Comparison of RMC green space per capita with existing standards.

Existing standards	**Descriptions**	**Shortages (m^2 / capita)**	**Affected Population**
World Health Organization standards: 9 m^2 /capita	In this condition 42 wards satisfy the standards and the remaining 28 Wards have shortage.	128 m^2 /capita, UGS is shortage in 28 wards (Average 4.6 m2)	43.75 % population of RMC is below than the WHO,UGS standard
The Urban and Regional Development Plans Formulation and Implementation (URDPFI, 2014) prescribed a standard of 10-12 m^2 /capita (Indian Smart City Guidelines)	In this condition 37 wards satisfy the standards and the rest 33 Wards have shortage.	220 m^2 /capita, UGS is shortage in 33 wards (Average 6.7 m^2)	50.28 % population of RMC is below than the Indian smart city standard

Ward wise per capita UGS is shown in Table 2 and it can be observed that the highest (428.21) and lowest (0.70) m^2 per capita green space are recorded in Sant Ravidas Ward and Bhramanpara Ward respectively. It is clear that almost half of RMC wards are below Indian smart city standards. The results also indicated that there is 1 ward (ward 44) below 1 m^2/capita green space which is very alarming to government authority.

Table 2. Ward wise per capita UGS.

Ward No	Ward Name	Total Population	UGS (sqm)	UGS / Capita
1	Veer Savarkar Nagar Ward	21781	1684900	77.35
2	Pt. Javaharlal Nehru Ward	35387	614400	17.36
3	Sant Kabir Das Ward	18224	225400	12.368
4	Yatiyatan Lal Ward	15398	131500	8.54
5	Banjari Mata Mandir Ward	19483	25300	1.29
6	Veerangani Avanti Bai Ward	9851	2941700	298.61
7	Kushabhav Thakre Ward	24272	1372600	56.55
8	Pt. Motilal Nehru Ward	14176	1564700	110.37
9	Dr. Bhimrav Ambedkar Ward	19108	392600	20.54
10	Rani Laxmi Bai Ward	12003	211300	17.60
11	Kalimata Ward	8452	118100	13.97
12	Mahatma Gandhi Ward	12749	62400	4.89
13	Rajiv Gandhi Ward	19914	92700	4.65
14	Raman Mandir Ward	12964	238200	18.37

15	Kanhiya Lal Banjari Ward	11047	84700	7.66
16	Veer Shivaji Ward	11961	74300	6.21
17	Thakkar Bapa Ward	8709	42600	4.89
18	Bal Gangadhar Tilak Nagar Ward	21984	100700	4.58
19	Dr. A.P.J. Abdul Kalam Ward	11167	42100	3.77
20	Ram Krishna Paramhans Ward	9541	167200	17.52
21	Shaheed Bhagat Singh Ward	10251	125900	12.28
22	Pandit Ishwaricharan Shukla Ward	11158	804800	72.12
23	Manmohan Singh Bakshi Ward	14285	387300	27.11
24	Vallab Bhai Patel Ward	9424	149700	15.88
25	Sant Ram Das Ward	13785	52400	3.80
26	Danveer Bhabhasaha Ward	15842	154300	9.74
27	Indra Gandhi Ward	32719	49800	1.52
28	Shaheed Hemu Kalyani Ward	27943	125700	4.49
29	Guru Govind Singh Ward	15401	34900	2.26
30	Shankar Nagar Ward	10874	116700	10.73

31	Netaj Subhas Chandra Bose Ward	11247	242200	21.53
32	Maharishi Valmiki Ward	10502	597900	56.93
33	Veernarayan Singh Ward	11055	50600	4.57
34	Lal Bahadur Shastri Ward	12782	245500	19.21
35	Pandit Ravishankar Shukla Ward	9514	94500	9.93
36	Havaldar Abdul Hamid Ward	9716	112900	11.62
37	Tatyapara Ward	7678	26700	3.47
38	Shaheed Chudamani Nayak Ward	13794	47500	3.44
39	Swami Atmanand Ward	8037	123500	15.36
40	Thakur Pyare Lal Ward	9094	536400	58.98
41	Pt. Dindayal Uppadhye Ward	8602	423500	49.23
42	Pt. Sundar Lal Sharma Ward	12134	105900	8.73
43	Mahant Laxminarayn Das Ward	16168	76800	4.75
44	Bhramanpara Ward	15406	10800	0.70
45	Swami Vivakanand Ward	17628	104000	5.89
46	Mailana Abdul Rauf Ward	34761	155300	4.47

47	Civil Lines Ward	10010	343200	34.28
48	Mother Terisa Ward	9740	21500	2.21
49	Guru Ghasidas Ward	12953	48000	3.70
50	Rani Durgavati Ward	12152	293600	24.16
51	Pt. Vidyacharan Shukla Ward	19504	2520500	129.22
52	Dr. Rajendra Prasad Ward	10644	306200	28.77
53	Babu Jagjivan Ram Ward	19627	554900	28.27
54	Kamred Sudhir Mukharjee Ward	14049	1089500	77.55
55	Ravindra Nath Taigore Ward	12281	150000	12.21
56	Arvind Dikshit Ward	9318	139500	14.97
57	Pt. Bhagwati Charan Shukla Ward	7594	204900	26.98
58	Shaheed Pankaj Vikaram Ward	8851	343700	38.83
59	Mureshwar Rao Gandre Ward	9057	63900	7.05
60	Chandrashekhar Aazad Ward	9663	238800	24.71
61	Dr. Shyam Prasad Mukhrji	11307	3908000	345.62
62	Shaheed Rajiv Pard Ward	20077	198900	9.91

63	Brigadier Usman Ward	16055	88300	5.49
64	Dr. Vipin Bihari Sur Ward	14568	50900	3.49
65	Mahamaya Mandir Ward	10763	551800	51.27
66	Vaman Rao Lakhe Ward	12234	63700	5.21
67	Bhaktmata Karma Ward	24503	1142900	46.64
68	Dr. Khubchand Baghel Ward	16578	28600	1.72
69	Madhav Rav Sapre Ward	24568	863200	35.13
70	Sant Ravidas Ward	6366	2726000	428.21
	Total	1010433	31083400	30.76

For the entire area of RMC the per capita green space is 30.76 m^2. It means that, as a whole, RMC consists of enough greenery for the better lifestyle and health of its residents, but when the ward wise UGS data is analysed, the distribution of the UGS is highly uneven, the areas which contains a lot of human interactions, fall short in fulfilling with either WHO or Indian smart city standards for per capita green space.

DISCUSSIONS

As the result shows that green spaces need to be uniformly distributed throughout the city area, and the total area occupied by green spaces in the city should be large enough to accommodate the city population needs. The Raipur city has the urban setup where UGS is not distributed evenly for the entire population. Wards with high requirements for green spaces are emphasized as critical areas that public decision makers need to focus on. The prepared map will help as a decision support tool to evaluate, quantify and compare various wards in the distribution of per capita green space. Rather than merely measuring the overall per capita green space in all wards, the result also shows the shortage of green space in critical wards to improve the quality of green spaces. Very low area of urban green spaces does not sustain the ward population which will lead to adverse impact on human physical and mental activity.

CHAPTER - 7
CONCLUSIONS

The study is clear evidence that the distribution of green spaces in the RMC is not in a very good condition. The wards have a shortage in per capita urban green space and it is not satisfying the global and national standards for a healthy urban environment. 28 wards come under most critical conditions because it has only less than 9 m^2 /capita UGS. As it's described earlier the green space per capita in RMC is equal to 30.76 m2 . According to WHO and smart cities standards, the calculated value for green space per capita must be equal to 10-12 square meters per capita, which is quite enough but ward wise this is not sufficient for good environmental conditions. As Raipur city has the urban setup where UGS is not distributed evenly for the entire population so this paper will help as a decision support tool to evaluate, quantify and compare various wards in the distribution of per capita green space. Rather than merely measuring the overall per capita green space in all the wards, the result also shows the shortage of green space in critical wards to improve the quality of urban green.

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