

# THE DECCAN GEOGRAPHER

---

Volume 62  Number 6  December 2024

---

(UGC Care Listed: A Peer Review and Refereed Journal)



*Chief Editor*  
**Professor B. C. Vaidya**

**THE DECCAN GEOGRAPHICAL SOCIETY, INDIA**  
**(ESTD : 1962)**

# THE DECCAN GEOGRAPHICAL SOCIETY, INDIA

The Deccan Geographical Society, India established in 1962 at Hyderabad (India) and started publication of Geographical Journal, namely, "The Deccan Geographer" since 1962 and "Bhugol- Shastra Sansodhak" Journal (Marathi+Hindi and English) since 2006. The journals are devoted to the publication of research papers in the diverse fields of Geography. Papers are invited on any of the themes involving the application of Geographical methodology and the research towards the solution of human problems. It includes papers on recent techniques and currents problems which deal with the issues related to the Environment, Social, Urban, Population and Food Security. The membership of journal is open for geographers, research scholars, planners, decision makers and allied disciplines. The interested persons can enroll for 5 years membership. The membership form is available on DGSI website:

**Website:** [www.thedecangeographer.com](http://www.thedecangeographer.com)

## "The Deccan Geographer" Journal

(UGC Care Listed Geography Peer Review Refereed Journal)

### Editorial Board

Chief Editor : Professor B. C. Vaidya : Managing Editor : Dr. Bimla Kumari

Dr. S. B. Singh (Varanasi)	Dr. B. Hemamalini (Waltaire)	Dr. Rolee Kanchan (Vadodara)
Dr. A. S. Raymane (Bangaluru)	Dr. Hemlata Patel (Pune)	Dr. Mohd. Reza Anvari (Iran)
Dr. D.H. Pawar (Kolhapur)	Dr. Kiran Kumari (Itanagar)	Dr. Uttam Lal (Gangtok)

### Peer Review Committee

Dr. B.R. Thakur (Shimla)	Dr. B.B. Sonule (Mumbai)	A.R. Siddiqui (Prayagraj)
Dr. KPR Menon (Trivendrum)	Dr. P.R. Vyas (Udaipur)	Dr. P. Andrew (USA)
Dr. Rio Alexander (USA)	Dr. A. Coleman (Canada)	Dr. A. Zaedi (England)

### Subscription to "The Deccan Geographer" Journal

Individual (Four Years)	: Rs. 4000/-	Library (Four Years)	: Rs. 4000/-
Foreign Member (One Year)	: US\$ 200/-	Foreign Member (Four Years)	: Rs. 1000/-

### Payment by Online

Account Name: The Deccan Geographical Society, India  
Bank Name: Bank of Maharashtra Branch: University of Pune  
Savings Account No.: 60002473706 IFSC Code: MAHB0001355

Note: (1) Screenshot of Online payment should be sent by mail to Dr. B C Vaidya  
(2) Demand Draft should be drawn in favor of 'The Deccan Geographical Society'  
payable at New Delhi/Pune

---

**Journal Subscription Address: Dr. B. C. Vaidya, Secretary General, DGSI, BE-5B, DDA Flats, Munirka, New Delhi-110 067 (Email- [vaidya2255@gmail.com](mailto:vaidya2255@gmail.com))**

**Contact: - Dr. B. C. Vaidya (9560901219) / Dr. Sapana Sasane (09967650959)**

**Society Address: Dr. Sapana Sasane, Secretary General, DGSI (Pune HQ.), The Deccan Geographical Society, India, Department of Geography, Savitribai Phule Pune University, Pune- 411007 (Maharashtra State) (E-mail: [sapnasasane@yahoo.com](mailto:sapnasasane@yahoo.com))**

---

Partially financial assistance received from ICSSR, New Delhi for this publication. Opinions Expressed in the articles are those of the contributors and do not necessarily reflect the policy of the DGSI Society.



## CONTENTS

- 
- |     |  |    |
|-----|--|----|
| (1) | A Geospatial Study of Population Density and Urban Green Space Dynamics in Kolkata Municipal Corporation, West Bengal<br><i>--Md. Julfikar Ali, Liyakat Ali and Moududa Khatun</i>                                 | 1  |
| (2) | Assessment of Vegetation and Land Use Change: A Spatio-Temporal Analysis of Jodhpur and Bikaner Districts of Western Rajasthan<br><i>--Dr. Lalit Singh Jhala, Mr. Ashok Gehlot and Mr. Vivek Raj Singh Chauhan</i> | 15 |
| (3) | Nanoparticles Unveiled-Harnessing The Power Of Groundnut Shells<br><i>--Usha, C. and Nandini, N</i>  | 26 |
| (4) | Precarity of Natural Resource-Based Livelihoods-A Study of the Vaddera Community, Telangana State<br><i>--Parupally Anjaneyulu and Sankineni Laxman Rao</i>  | 36 |
| (5) | Identifying Inter-Linkages between Family Networks and Inter-State Marriage Migration in Rohtak District, Haryana<br><i>--Kavita Singh and Professor Smita Bhutani</i>   | 50 |
| (6) | Decadal Analysis of Net Sown Area and Gross Crops under Food Cropped in Jaunpur District, Uttar Pradesh<br><i>--Divya Tiwari and Dr. Abhishek Dubey</i>  | 61 |
| (7) | Spatio-Temporal Study on Population Dynamics and Forecasting In East Siang District Of Arunachal Pradesh, India<br><i>--Diram Bori, Trisha Deka, Satyabrat Sonowal and Dr. Shukla Acharjee</i>                     | 69 |
| (8) | Quantification of Probability of Recurrence of Meteorological Drought in Mysuru City, Karnataka<br><i>--Dr. Prasanna Kumar K R</i>   | 78 |
-

---

(9)	Fluvio-Geomorphological Study on Hydrograph and Flood Frequency Analysis of Pagladiya River in Assam	85
	<i>--Dr. Dipak Baruah and Dr. Safiqur Rahman</i>	
(10)	Spatio-Temporal Changes in Vegetation Cover of the Majhuee River Basin in Phoolpur Tehsil in Azamgarh District	99
	<i>--Shivam Singh and Ashwajeet Chaudhary</i>	
(11)	Growth and Challenges of Tourism Development in Varanasi City, Uttar Pradesh	108
	<i>--Anand Kumar Soni and Dr. Amit Kumar Chaturvedi</i>	
(12)	Impacts of Floods in Cheyyeru River- A Study of Rajampeta Revenue Division in YSR Kadapa District, Andhra Pradesh	122
	<i>--N. Sreedhara Naidu</i>	
(13)	Impacts of Floods in Cheyyeru River- A Study of Rajampeta Revenue Division in YSR Kadapa District, Andhra Pradesh	136
	<i>--N. Sreedhara Naidu</i>	
(14)	Dynamics of Agricultural Infrastructure and Development in Rajasthan	147
	<i>--Dr. Pramila Kumari Sharma</i>	
(15)	Assessment of Landuse and Landcover Changes and Spectral Indices in Varanasi City, Uttar Pradesh	162
	<i>--Nazreen Khanam, Lubna Siddiqui, Dr. Masood Ahsan Siddiqui, Dr. Braj Raj Kumar Sinha and Dr. Intikhab Ahmad</i>	
(16)	Spatial Analysis of Crime Hotspots using Moran's I and Getis-Ord Gi* Statistics in Jaipur City, India	174
	<i>--Tanisha Sharma and Cheetar Mal Meena</i>	
(17)	Assessment of Green Cover Sustainability-A Case Study of Sonipat City	186
	<i>--Dr. Seema and Dr. Mehtab Singh</i>	
(18)	Beyond The City Edges, Urban Expansion in Peri-Urban Hisar, India- A Landscape Metrics and Shannon Entropy Index Approach	199
	<i>--Rahul and Ravinder Kaur</i>	

---

---

(19)	Regional and Temporal Trend of Child Population Sex Ratio in Karnataka	220
	<i>--Dr. Saritha K. and Dr. S. Srikanta Prasad</i>	
(20)	Assessment of Sanitation Facilities and Waste Disposal Practices in Selected Slum Areas of Upper Assam, India	234
	<i>--Preeti Barsha Borah and Lanusashi Longkumer</i>	
(21)	Assessment of Food Waste Awareness of Stakeholders in Ajmer, Rajasthan	246
	<i>--Atul Jain, Dr. Rashmi Sharma and Dr. Ashutosh Kumar Pandey</i>	
(22)	Assessment of Agriculture Development in Uttar Pradesh	258
	<i>--Ahmad Mujtaba Siddiqui, Tariq Mahmood Usmani and Afa Aslam</i>	
	Membership Form	270

---

The Deccan Geographical Society of India  
Department of Geography  
Savitribai Phule Pune University, Pune (Maharashtra)



## **A GEOSPATIAL STUDY OF POPULATION DENSITY AND URBAN GREEN SPACE DYNAMICS IN KOLKATA MUNICIPAL CORPORATION, WEST BENGAL**

Md. Julfikar Ali, Liyakat Ali and Moududa Khatun

### **Abstract**

Vegetation cover can purify the natural environment of a city and improve physical health, mental health and well-being of the city dweller. Unplanned urbanization shrinks the urban greens therefore damaging the health and well-being of citizens. This study analyses the Urban Green Space (UGS) change and subsequent change in per capita UGS. Geospatial tools have been used for the change detection of UGS in Kolkata Municipal Corporation (KMC). UGS has been estimated to be continuously declining over time in the city of Kolkata. The study reveals a decline of UGS, blue space (water body), therefore, a decline of per capita UGS availability, and a tremendous increase of built-up area. Subsequently, the availability of green space in KMC fall down from 10.75 m<sup>2</sup>/person in 1989 to 8.37 m<sup>2</sup>/person in the year 2000, 4.43m<sup>2</sup>/person in 2010 and 5.16 m<sup>2</sup>/person in 2019.

### **Introduction**

Urban Green Spaces (UGSs) are the areas of vegetation covered in the city. Because of its immense importance, it is being called the ‘green lungs’ of a city which improves the physical and mental health of the city dwellers. Vegetation or urban greens significantly control the surrounding environment of a green area and improve human health (Ihlebaek et al., 2018). UGS enhances the quality of urban settings, increases sustainability (Baycan-Levent et al., 2002 and Hepcan, 2013), develops local resilience and improves the overall health and wellbeing of urban residents (Huang et al., 2017). The rapid acceleration of the urban population and increasing demand for land significantly reduces the vegetation cover (Berg et al., 2010). Simultaneously if the development and management of UGS do not get priority, it may set on shrinking and worsen continuously specifically in congested cities like Kolkata. It is also important to note that the world’s urban population is booming and is expected to be 6.6 billion by 2050 and India’s urban

population is expected to be 876 million by 2050 (United Nations, 2018) which must be a threat to the quantity and quality of UGS. The fast surge of urbanization reduces the per capita availability of UGS over time. The pace of urbanization and UGS availability can best be balanced for citizen's healthy living only through urban planning. Kolkata is one of the most populated cities in India and has a very meagre amount of per capita availability of UGS. Assessment of the spatial distribution of the UGS is important for planning and design of UGSs to get more health benefits (Huang et al., 2017).

### **Study Region**

KMC is India's one of the largest and oldest municipal corporation and is more than 300 years old city (Mitra et al., 2011). It is located in the eastern part of India and the southern part of West Bengal. Kolkata is bounded by Howrah on the west, North 24 Parganas on the north and east, South 24 Parganas on the south. Total population of KMC is 4496694 persons (Census of India, 2011). The population density of Kolkata is 24252 per square kilometre. This is one of the most crowded cities in the country. However, KMC has been selected as a study area because it is a denser, more built-up area but less green and blue space cover.

### **Objectives**

- (1) To analyse the dynamics of UGS and subsequent changes in per capita availability of UGS in Kolkata Municipal Corporation, and
- (2) To assess urban dwellers' health perspectives and well-being over the years in an evidence-based theoretical approach.

### **Database and Methodology**

The study is mainly based on the secondary data. Satellite images for the years 1972, 1989, 2000, 2010 and 2019 have been obtained from the United States Geological Survey (USGS) Earth Explorer repository. These satellite images are of February or March month of the concerned year, except the satellite image of 1972 which is of December due to the unavailability of the cloud-free image of February or March. Thus, the collected base map of KMC was imported to Arc-GIS for geo-referencing, projecting and coordinating with the same projection and coordinate system as obtained satellite images. LULC classification has been done with the help of supervised classification for UGS analysis. With the signature pixels four LULC categories have been classified i.e., Vegetation, Water Body, Built up and Fallow Land/open space. Finally, with the help of the supervised

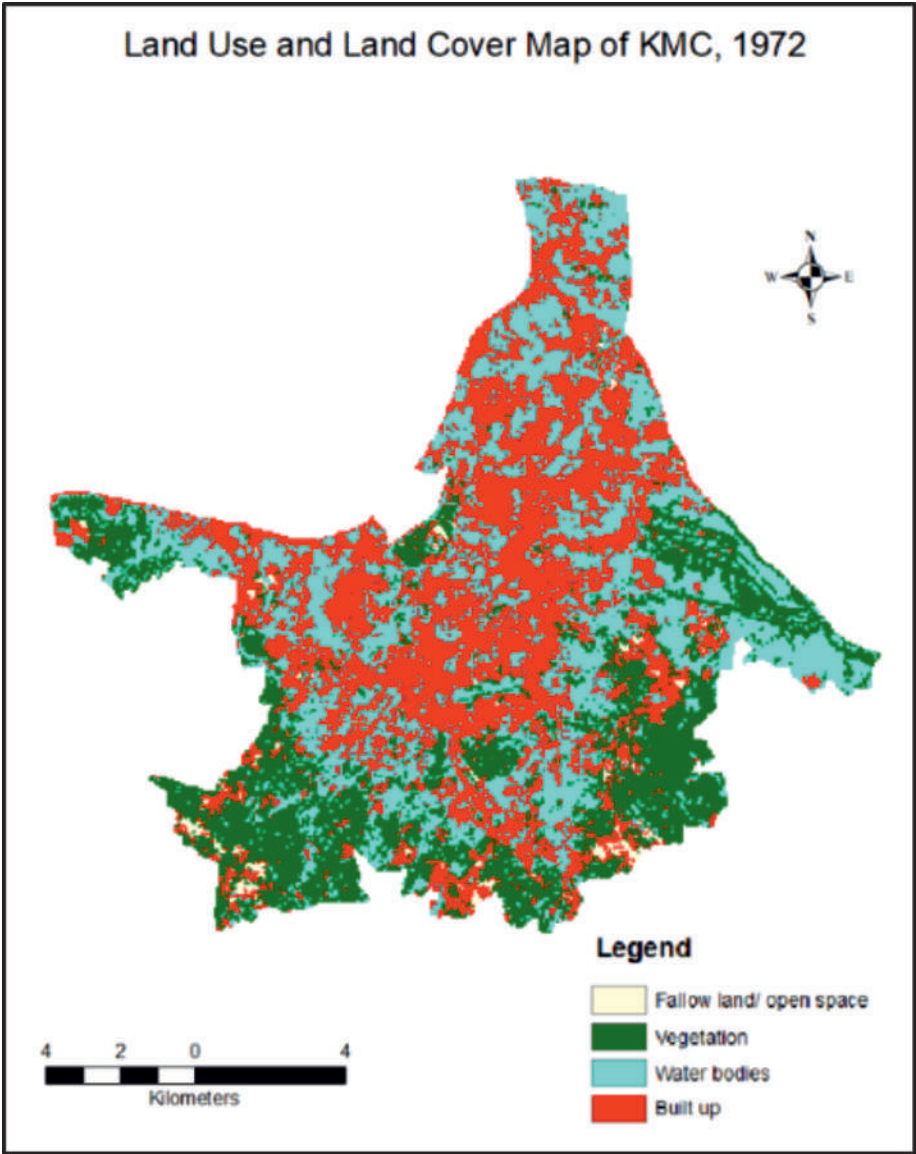


Fig. 1

classification process, the classified LULC map has been prepared. Thereafter, the post-classification comparison method has been used to measure the dynamics of LULC change. Per capita UGS availability of KMC has been estimated on the basis of projected population figure from the population data of 1971, 1981, 1991, 2001 and 2011 collected from Census of India. Simple arithmetic method of population projection has been employed to find out the population data of the targeted study years. It was projected on the basis of annual progression of census population between two consecutive census years of targeted study year. Total UGS area of the targeted study years has been estimated from the supervised image classification. Finally, per capita UGS availability has been estimated by dividing the total UGS area by the total projected population of each year. Population density for the study year has been estimated on the basis projected population. The sample municipal wards for micro-level deliberation have been selected based on a stratified sampling method. All 141 wards have been grouped into five strata on population density figure (i.e., very high, high, moderate, low and very low population density) and two wards from each stratum were selected one being the highest and another lowest share of UGS area. The area under UGS has been estimated from supervised image processing in the same way as UGS for the entire KMC has been estimated.

## **Result and Discussion**

The concentration of vegetation cover is mainly at the edges of the city's boundary. However, it seems to be more concentrated in the eastern and southern portions of KMC. The northern and central portions show low dense vegetation cover. Some small patches of low to moderate dense vegetation cover are found near the lakes and playgrounds. In common parlance, UGS comprises various type of urban greens within the urban limit. In KMC, the UGS has been measured in terms of the LULC category entitled 'Vegetation'. Different types of UGS in KMC are Park, rooftop greens, road and street side greens, lake, pond and canal side greens, grass on open spaces, greens of playground and greens along the rail line, informal greens and greens of the zoological garden. Among these types of UGS, park is an important unit from the perspective of physical as well as psychological health of the city residents. The analysis of LULC change shows a gradual decline in vegetation (urban greens) cover 1972 onwards. It records a maximum decline of -1816.2 hectares of area under urban greens was recorded during 2000-2010 (Fig. 1). This figure of decline in urban greens was followed by -858.24 hectares during 1989-2000 and -312.21 hectares during 1972-89. During 2010-19, the green space found a little bit increased by 285.48 hectares.

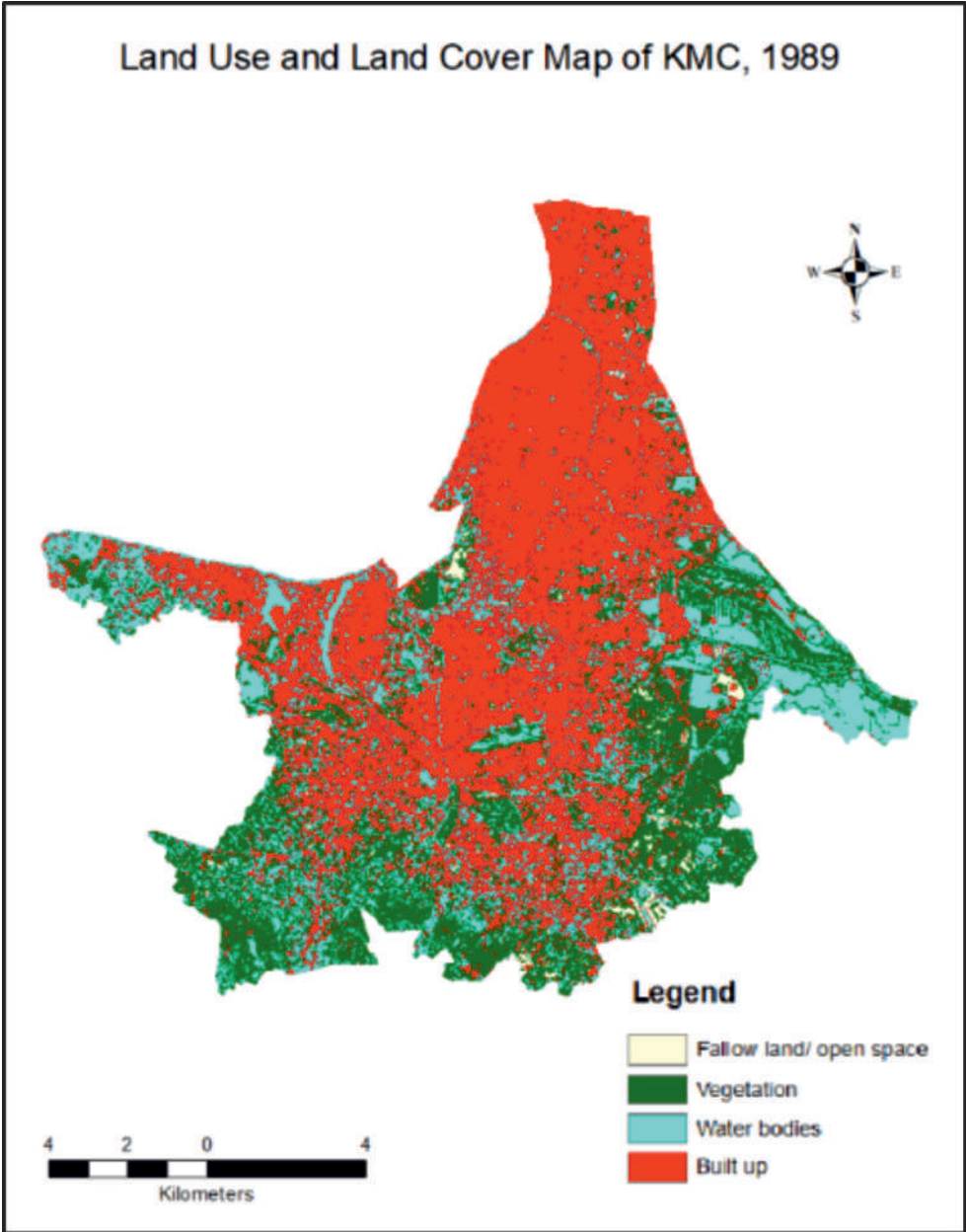


Fig. 2

However, an overall urban green cover of 26.84% in 1972 has been detected to decline to 12.29% in 2019 in KMC. On the other hand, image processing for LULC change shows a gradual decline of urban blue spaces since 1972. Urban blue space has been detected to decrease from 32.97% in 1972 to 8.82% in 2019 in KMC. However, a variable amount of change has been observed across the years under study. The highest amount of -2101.68-hectare water body has been detected to decline during the years 1972-1989, followed by -1359.9 hectares during 2000-2010, -978.2 hectares during 2010-2019 and -45.45 hectares during 1989-2000. Assessment of LULC change shows a continuous increase of built-up area since 1972. It shows a sharp-rising trend of built-up cover from 38.88% in 1972 to 78.73% in 2019 in the city. An amount of 3383.37 hectare has been detected to increase in the built-up cover during the period 2000-2010 followed by an increase of 2393.64 hectares during 1972-89, 862.92 hectares during 1989-2000 and 759.60 hectares during 2010-2019. Built-up category gained the area from the area lost under the categories of vegetation and water body. In the year 1972, a scattered built-up area was recorded, but the vegetation cover seems to be concentrated in some pockets of south-east and south-west areas of KMC (Fig. 2). In 1989, built-up area was found to be concentrated in the northern and central parts of the city, whereas the vegetation and water bodies were concentrated in the eastern and southern fringe areas. In 2000, a maximum built-up area was found to be extended to the southern direction and the vegetation remains at the eastern and southern fringe. Figure shows a huge transformation in the land use in 2019.

In this year almost green areas are transformed to red representing built-up areas. Change of vegetation due to shifting to other land use groups deliberates a warning for the concern of healthy urban living. It reveals that the city's built-up area has been mainly developed by replacing the vegetation cover and water bodies during the study time from 1972 to 2019. Thus, it can be summarised from the analysis that the built-up area has increased by gaining land from urban green space and urban blue space. From a health and well-being perspective, a standard norm of UGS is found variable across the countries. Developed countries consider 20 m<sup>2</sup> of park areas per capita as the standard for healthy living, whereas the United Nations considers 60 m<sup>2</sup> of park areas per person as the ideal UGS (Mohapatra & Mohamed, 2015). The WHO suggested a minimum standard i.e., at least a minimum availability of 9 m<sup>2</sup> green space per dweller (Kuchelmeister, 1998). Per capita UGS availability is different among the Indian cities. Few planned cities like Chandigarh and Jaipur maintain the standard norm of UGS (i.e., 54.45 m<sup>2</sup> and 20 m<sup>2</sup> per person respectively), while cities like Hyderabad, Ahmedabad, Chennai,

Surat, Mumbai and Ludhiana have less than 4 m<sup>2</sup> of UGS per person (Singh, 2018 & Govindarajulu, 2014) (Table-1). WHO guidelines are the pathfinder and guide to understanding the UGS status at the local level. Similarly, WHO guidelines have been studied and have been used to understand the status of UGS in a citizen's health perspective in KMC.

Table-1: Area and Percentage Share of Different LULC in KMC

Year of analysis	LULC Category					Per capita UGS (sq.m.)
	Estimated area	Vegetation	Waterbody	Built up	Fallow land / open space	
1972	Hectare	4984.2	6123.24	7220.84	242.28	13.23
	%	26.84	32.97	38.88	1.3	
1989	Hectare	4671.99	4021.56	9614.48	262.53	10.75
	%	25.16	21.65	51.78	1.41	
2000	Hectare	3813.75	3976.11	10477.4	303.3	8.37
	%	20.54	21.41	56.42	1.63	
2010	Hectare	1997.55	2616.21	13860.77	96.03	4.43
	%	10.76	14.08	74.64	0.52	
2019	Hectare	2283.03	1638	14620.37	29.16	5.16
	%	12.29	8.82	78.73	0.16	

Source: LULC of 1972, 1989, 2000, 2010 and 2019 based on supervised image classification, and population estimated (based on simple arithmetic progression between consecutive census years) from Census of India 1971, 1981, 1991, 2001, and 2011.

Note: Total area of KMC has been estimated to be 18570.56 Hectares while the total area of KMC as published by the Census of India is 18500 hectares (or, 185 sq. km). This is a little difference (i.e., 70.56 hectares or 0.71 sq. km) is occurred due to the error in image processing. For land use category-related assessment, an estimated area of 18570.56 hectares and for population-related assessment a total area of 18500 hectares has been considered.

In this study, a gradual decrease in green cover has been estimated since 1972. Per capita green space has been estimated based on the estimated UGS amount and population. It is observed that until 1989, KMC had a UGS of more than 9 m<sup>2</sup> per person which fulfils the minimum standard as recommended by WHO. Later, KMC failed to meet the standard level of UGS until 2010.

Although the per capita UGS of 2019 data shows a little increase from the previous study time, the figure still lies below 9 m<sup>2</sup> UGS per person. The continuous decline of per capita UGS availability in KMC has happened due to factors like continuous loss of vegetation cover and an increase in the population. In the year 1972, the total UGS of KMC was estimated at 4984.20 hectares, which is 26.83% of the KMC area. Population density (based on projected population) and per capita UGS at the same time was 20362 persons per km<sup>2</sup> and 13.23 m<sup>2</sup> (i.e., above the WHO recommended standard) respectively. In 1989, the total population had increased from 3767002 persons in 1972 to 4345224 persons (an increase of 15.35%). Population density had increased to 23488 persons per km<sup>2</sup> in 1989 (an increase of 15.35%). Land use change caused to decline in the amount of UGS from 4984.20 hectares in 1972 to 4671.99 hectares in 1989 meaning a decline of -6.26%. Subsequently, the city recorded 25.16% of its area under green cover and per capita UGS availability simultaneously declined from 13.23 m<sup>2</sup> in 1972 to 10.75 m<sup>2</sup> in 1989 because of declining UGS and an increase in the city's population. It is fine to see the status of the city's per capita UGS higher than the WHO standard figure of 9 m<sup>2</sup> in 1972 and 1989, but the city's UGS figure falls below it in the years 2000 to 2019. In 2000, KMC recorded an increase in absolute population, therefore population density further up stretched to 24625 persons per km<sup>2</sup>. Simultaneously further land use change caused to decline for UGS to 3813.75 hectares (20.54%) by -18.37%. The subsequent impact is visible in the declined figure of per capita green availability as estimated at 8.37 m<sup>2</sup> per person. This year marks the per capita UGS below the WHO standard for the first time in KMC.

In 2010, a huge land under green space was reduced to only 1997.55 hectares, which shares only 10.76% of the city's total area. The city experienced a decline in green cover by -47.62% between the years 2000 and 2010. Therefore, the per capita UGS availability drastically declined to 4.43 m<sup>2</sup> which is far below the WHO standard. As per the data record of the Census of India 2001 and 2011, KMC has experienced a negative population growth. A similar decline in population figure is noticed in the projected population of study time 2000 to 2010, therefore declining population density too (Table-2). Land use change has been observed to be the sole factor of the decline of per capita green space availability in the city during the study time from 2000 to 2010. In 2019, the UGS has been estimated to increase a little bit but remains below the WHO standard. In this year, UGS cover has increased to 2283.03 hectares which shares 12.29% city's area. Subsequently, the per capita UGS has been estimated to increase from 4.43 m<sup>2</sup> in 2010 to 5.16 m<sup>2</sup> in 2019.

Table-2: Temporal Changes in Population Density and Per capita UGS in KMC (1989-2019)

Selected Ward No.	Population Density (Person per sq. km)#			UGS share (%) to total geographical area			Per capita UGS (sq. meter per person)					
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	1989	2000	2010	2019	1989	2000	2010	2019	1989	2000	2010	2019
1	39540	36871	39936	38760	0.09	0.49	0.48	0.65	0.02	0.10	0.13	0.17
39	114755	127205	93636	106963	0	0.56	0.56	0.56	0	0.14	0.14	0.11
40	93877	77365	65052	56628	0	0	0.17	0.17	0	0	0.02	0.08
46	17687	19128	18924	16781	11.51	8.06	8.59	8.89	6.51	5.21	4.49	5.01
54	123994	129603	115577	123860	0	0.27	0.27	0.27	0	0.02	0.02	0.02
56	79435	78618	79256	79821	1.74	4.17	3.09	3.01	0.22	0.66	0.39	0.38
63	10238	9871	7266	9724	29.46	26.51	30.58	30.69	28.78	25.83	25.07	23.85
64	45153	37823	44060	45179	7.55	1.36	0.67	0.67	1.67	0.36	0.18	0.15
66	19506	23375	32067	27506	10.41	4.58	8.61	1.88	5.34	1.96	2.38	0.68
90	20977	21838	18346	19098	27.62	26.42	6.40	6.57	13.17	12.10	2.93	3.44

Source: Area under UGS has been estimated from supervised image processing and the population estimated from Census of India 1971, 1981, 1991, 2001 and 2011

Note: # Estimated (interpolated) population from Census of India, based on simple arithmetic progression between two concerned consecutive census years

The analysis reveals a continuous decline in per capita availability of UGS in the city and a simultaneous increase in population density with a little exception in 2010 and 2019. The increase of UGS during this period is the result of the successful implementation of the Green City Mission by the government of West Bengal. The program aimed to green the city through the plantation and their management. It includes urban afforestation, creation and revival of parks, nurseries, floriculture, pocket forests and plantations along the median of the roads (Government of West Bengal: Urban Development and Municipal Affairs Department, 2019). From the globally researched agenda of the impact of UGS on people's health and well-being (Berg et al., 2010; Huang et al., 2017; WHO, 2017; WHO, 2016), it can be argued that a decline of UGS in absolute or in per capita figure is a serious health concern of the city dwellers. KMC is witnessing a continuous decline of urban greens in terms of land share under green cover as well as per capita green availability which is a serious issue from the perspective of healthy city living.

The analyses the temporal change of population density, proportion of UGS to total geographical area and per capita UGS availability in selected wards of KMC. A causative association of per capita UGS change is profoundly found with the change of area under UGS in each ward. While a change in population density defines the population change, the change of area under UGS defines the land use transformation that is found to be more effective for the change of per capita UGS (Fig. 3). A drastic decline in the UGS is observed in ward no. 90 where 27.62% area was covered under greens in the year 1989 which declined to 26.42% in 2000, 6.40% in 2010, and 6.57% in 2019. Subsequently, a decline in per capita UGS has been observed with 13.17 m<sup>2</sup> per person in 1989, 12.10 m<sup>2</sup> in 2000, 2.93 m<sup>2</sup> in 2010 and 3.44 m<sup>2</sup> in 2019. A decline in UGS with a quite similar magnitude has been recorded in ward no. 66 where about 10.41% of the area was under green cover in 1989, which declined to 1.88% in 2019. This has resulted in the per capita UGS declining from 5.34 m<sup>2</sup> in 1989 to 0.68 m<sup>2</sup> per person in 2019. It is worth noting that only ward no. 63 with a per capita UGS of 23.85 m<sup>2</sup> per person in 2019 has been observed to cross the minimum requirement of 9 m<sup>2</sup> per person UGS for healthy city living (as per WHO) and the rest of the wards fall below this benchmark. As lowest 0.08 m<sup>2</sup> UGS per person has been observed in ward no. 40. Comparatively a little change in both shares of green area as well as per capita UGS has been estimated in ward no. 63, 56, and so on. In general, almost all sampled wards indeed experienced a decline in the per capita UGS with some exception of a little increase in the year 2019 from 2010 (Table-2). It is very clear from the analysis that a decline in the per capita

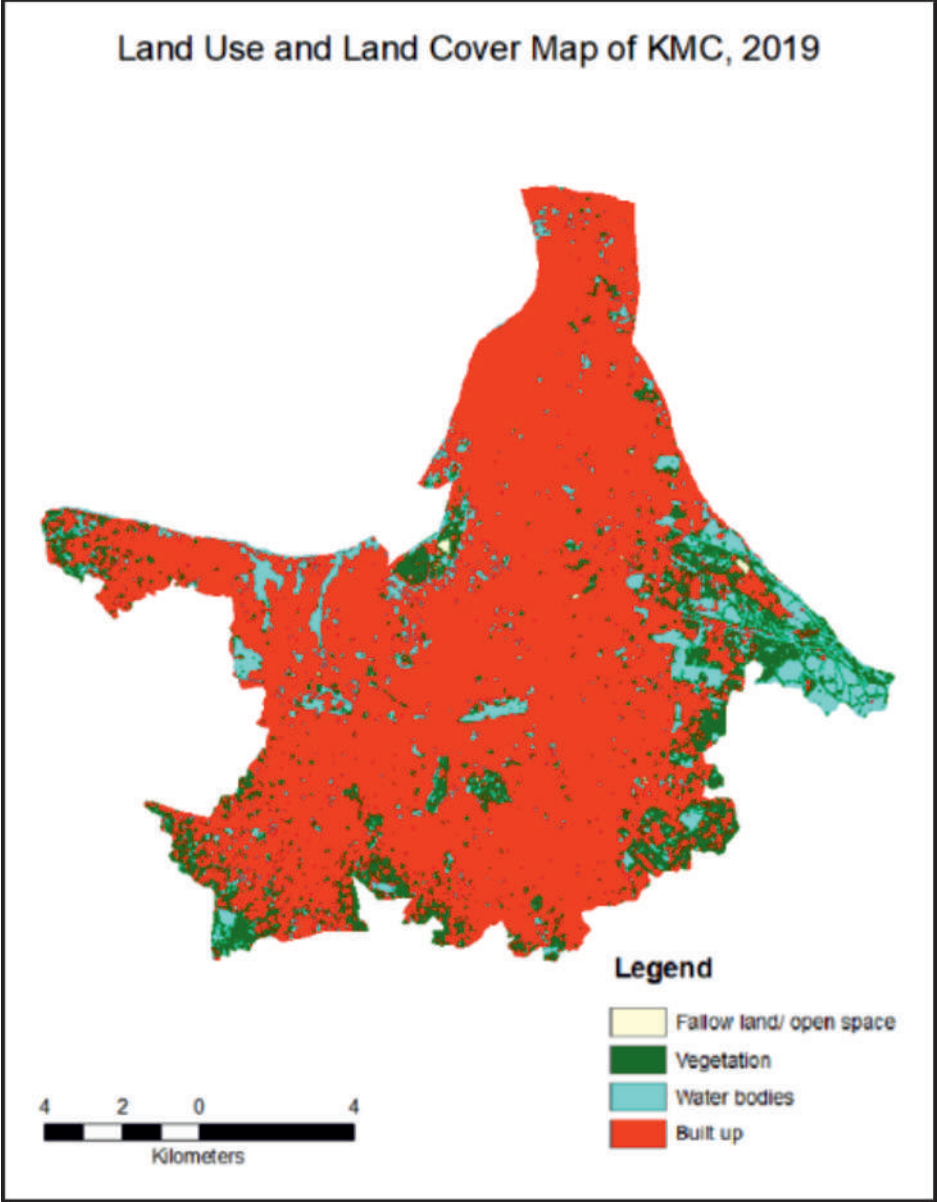


Fig. 3

UGS or an absolute area under UGS has happened due to the dual factors of land use change wherein the built-up category has gained a larger area from the urban green area. Secondly, population change in KMC as a whole. However, the regularity of change in per capita UGS corroborates more with the change in area under UGS than the population change.

## **Conclusion**

Literature of the work done so far considers UGS as one of the most important healthy-living infrastructures of the city, as it is capable of providing multiple health benefits directly and indirectly. Direct health benefits from UGS can be achieved through regular visits by urban dwellers. Psychologically people get enchanted while visiting a park. Per capita availability of green space is an important indicator of how far the city provides opportunities for healthy living to its dwellers. The analysis finds a noticeable increase in urban built-up areas at the loss of urban vegetation. Although, the study incorporates all kinds of vegetation cover irrespective of their usability still a populated city like Kolkata has a very low per capita UGS than that of the WHO recommended minimum standard. The continuous increase of built-up and change in population results in a decrease in per capita UGS availability. The continuous fall of UGS availability and its going down the WHO minimum standard poses a serious threat to the healthy living of citizens in KMC. The city planners and urban managers must take up the issue of urban greening that may be incorporated in the city planning and design. An increase in area under UGS will increase per capita UGS generally happens through the initiative of urban greening activities like the development of new parks and gardens, and also street plantation in the city by local planning agencies.

## **References**

- Baycan-Levent, T., Leeuwen, E. V., Rodenburg, C. & Nijkamp, P. (2002). Development and Management of Green Spaces in European Cities: Comparative Analysis. 38th International Planning Congress, Athens, Greece, 1-12
- Berg, A. E., Maas, J., Verheij, R. A. & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science and Medicine*, 70, 1203–1210.
- Bhaskar, P. (2012). Urbanization and changing green spaces in Indian cities (case study-city of Pune). *International Journal of Geology, Earth and Environmental Sciences*, 2 (2) 148- 156
- Census of India (1971, 1981, 1991, 2001, 2011). District census handbook of Kolkata.
- Chaudhry, P., Bagra, K., &Sing, B. (2011). Urban Greenery Status of Some Indian Cities: A Short Communication, *International Journal of Environmental Science and Development*, 2 (2), 98-101. DOI: 10.7763/IJESD.2011.V2.104

- Government of West Bengal: Urban Development and Municipal Affairs Department. (2019). Retrieved from Green City, Clean City – A New Mantra for West Bengal. [https://www.wburbanservices.gov.in/page/cms/green\\_city\\_mission](https://www.wburbanservices.gov.in/page/cms/green_city_mission)
- Govindarajulu, D. (2014). Urban green space planning for climate adaptation in Indian cities. *Urban Climate*, 10 (1), 35-41. <https://doi.org/10.1016/j.uclim.2014.09.006>
- Gupta, K., Kumar, P., Pathan, S. K., & Sharma, K. P. (2012). Urban Neighbourhood Green Index – A measure of green spaces in urban areas. *Landscape and Urban Planning*, 105 (3), 325–335. <https://doi.org/10.1016/j.landurbplan.2012.01.003>
- Hepcan, S. (2013). Analyzing the pattern and connectivity of urban green spaces: A case study of Izmir, Turkey. *Urban Ecosyst*, 16, 279–293. <https://doi.org/10.1007/s11252-012-0271-2>
- Huang, C., Yang, J., Lu, H., Huang, H., & Yu, L. (2017). Green Spaces as an Indicator of Urban Health: Evaluating Its Changes in 28 Mega-Cities. *Remote Sensing*, 9 (12) 1266. <https://doi.org/10.3390/rs9121266>
- Ihlebaek, C., Aamodt, G., Aradi, R., Claussen, B., & Thoren, K. H. (2018). Association between urban green space and self-reported lifestyle-related disorders in Oslo, Norway. *Scandinavian Journal of Public Health*, 46 (6), 589–596. DOI: 10.1177/1403494817730998
- Imam, A.U.K. & Banerjee, U.K. (2016). Urbanisation and greening of Indian cities: Problems, practices, and policies. *Ambio*, 45, 442–457. <https://doi.org/10.1007/s13280-015-0763-4>
- Ji, F. Q., & Chu, J. L. (2013). On the Strategies of Optimizing the Landscape of the Urban Green Space: based on ecological security. *Applied Mechanics and Materials*, 357-360, 2014-2017. DOI: 10.4028/www.scientific.net/AMM.357-360.2014
- Kuchelmeister, G. (1998). Urban Forests: Present Situation and Prospects in the Asia Pacific region. FAO Asia-Pacific Forestry Sector Outlook Study, FAO Working Paper No: APFSOS/WP/44 (Food and Agriculture Organization of the United Nations, Rome)
- Mabon, L., & Shih, W. Y. (2018). Mapping the socio-political landscape of heat mitigation through urban greenspaces: the case of Taipei Metropolis. *Environment and Urbanization*, 31 (2), 552-574. <https://doi.org/10.1177/0956247818767318>
- Mitra, C., Shepherd, M., & Jordan, T. (2011). On the relationship between the premonsoonal rainfall climatology and urban land cover dynamics in Kolkata city, India. *International journal of climatology*, 32 (9), 1443–1454. DOI: 10.1002/joc.2366
- Mohapatra, B., & Mohamed, A. R. (2015). The Effect of Social and Spatial Processes on the provision of Urban open spaces: the case of Bhubaneswar in India. *International Journal of Green Economics*, 9 (1). DOI: 10.1504/IJGE.2015.067889
- Siddique, G., Roy, A., Mandal, M.H., Ghosh, S., Basak, A., Singh, M., & Mukherjee, N., (2022), An assessment on the changing status of urban green space in Asansol city, West Bengal, *GeoJournal*, 87, 1299–1321, <https://doi.org/10.1007/s10708-020-10312-2>
- Singh, K.K., (2018). Urban green space availability in Bathinda city, India. *Environ Monit and Assess*, 190 (671). <https://link.springer.com/article/10.1007/s10661-018-7053-0>
- United Nations. (2018). World Urbanization Prospects: The 2018 Revision. Department of Economic and Social Affairs, Population Division.

WHO (2016), Urban green spaces and health: A review of evidence, Copenhagen: WHO Regional Office for Europe, 22-23, retrieved from [https://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf](https://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf), on 22.10.2022

WHO. (2017). Urban Green Space Interventions and Health: A review of impacts and effectiveness. Working Paper, Copenhagen: World Health Organization.

--Md. Julfikar Ali  
Assistant Professor & Project Director  
(IMPRESS- ICSSR, Government of India)  
Department of Geography  
Aliah University, Kolkata (West Bengal)

--Liyakat Ali  
UGC-Senior Research Fellow  
Department of Geography  
Aliah University, Kolkata (West Bengal)

--Moududa Khatun  
Assistant professor  
Department of Geography  
Aliah University, Kolkata (West Bengal)



## **ASSESSMENT OF VEGETATION AND LAND USE CHANGE: A SPATIO-TEMPORAL ANALYSIS OF JODHPUR AND BIKANER DISTRICTS OF WESTERN RAJASTHAN**

Dr. Lalit Singh Jhala, Mr. Ashok Gehlot and Mr. Vivek Raj Singh Chauhan

### **Abstract**

This research investigates the spatio-temporal dynamics of vegetation and land use change in the Jodhpur and Bikaner districts of Western Rajasthan. Utilizing Landsat 7 and 8 satellite data from the years 2001, 2010, and 2024, we perform a comprehensive analysis of land use and land cover (LULC) changes using ERDAS IMAGINE software. The analysis reveals significant landscape transformations. These are primarily driven by rapid urban expansion. There are considerable reductions in forested areas and vegetation cover. Urban areas increased significantly indicating ongoing urbanization. Variations in barren land suggest changing land management practices and environmental conditions. The accuracy assessment, based on overall accuracy and Kappa coefficient metrics indicates high reliability in 2001. There is a decrease in 2010 due to increased LULC complexity. Improvement is noted in 2024, reflecting advancements in remote sensing technology. NDVI analysis shows moderate vegetation cover in 2001. Slight improvement occurred in 2010. There is a significant overall improvement by 2024 despite less dense vegetation areas. These findings highlight the need for sustainable land management. It is crucial to balance urban growth with natural ecosystem conservation. Continuous monitoring is essential. Advanced methodologies help understand and manage environmental changes. This provides valuable insights. Policymakers and stakeholders can develop effective sustainable land use and resource management strategies.

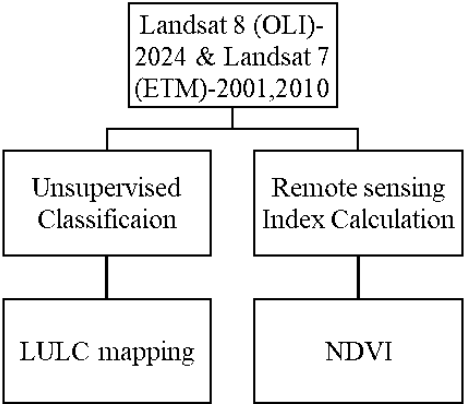
### **Introduction**

Understanding the impacts of modifications in land use and land cover (LULC) on the environment is crucial for both natural processes and human activities (Getahun and Yoseph, 2022). Over the past decade, the normalized difference vegetation index (NDVI) differencing method and classification method have been

widely used for change detection, providing detailed information for detecting and monitoring changes in land use-land cover (LULC)(Ehsan and Kazem, 2013). Recently, the demand for highly accurate and detailed land-use and land-cover (LULC) data has increased due to the growing complexity of Earth's processes (Idrees et al., 2022). Satellite imagery and remote sensing technologies have revolutionized the monitoring and assessment of these changes by providing reliable information across extensive geographic areas (Lu et al., 2013). Satellite-derived indices, such as the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Built-up Index (NDBI), are vital for gaining insights into various environmental factors(Jothimani et al., 2021), including vegetation health, water presence, and urbanization. The NDVI classification, the most commonly used method for plant classification, was applied, and separate data was acquired for each image (Özyavuz et al., 2015). Common change detection methods include comparing land cover classifications, multi-date classification, band arithmetic, simple ratioing, vegetation index differencing, and change vector analysis (Jomaa and Kheir, n.d.). Jodhpur and Bikaner, prominent cities in Rajasthan, India, serve as exemplary cases for analyzing LULC dynamics. Situated in the Thar Desert, both cities experience dry and semi-arid climates (Kar et al., n.d.), presenting unique challenges for environmental management and sustainable development. Over the past few decades, Jodhpur and Bikaner have undergone significant changes in land use and urban growth due to population increase, economic development, and tourism (Saharan et al., 2018). The NDVI, a remote sensing index, is particularly useful for extracting vegetation data and has been extensively used to evaluate vegetation cover in the region (Mancino et al., 2014). NDVI values range from -1 to 1, with high values indicating dense vegetation and low values representing non-vegetative areas.

### **Study Region**

The study area for this research encompasses the Jodhpur and Bikaner districts, located in the arid region of Western Rajasthan, India. Jodhpur district, covering 22,850 km<sup>2</sup>, is situated in the western part of Rajasthan. It lies between latitudes 26°00' N and 27°31' N, and longitudes 72°55' E and 73°52' E (Beg et al., 2013). Bikaner positioned between latitudes 27°11' N and 29°3' N, and longitudes 71°54' E and 74°12' E. It is bordered to the north by the district of Sri Ganganagar, to the west by Jaisalmer and Pakistan, to the east by Churu, and to the southeast by Nagaur and Jodhpur. Bikaner district covers an area of 27,244 km<sup>2</sup> (“Marudhara Academy,” n.d.). The total area of both the district are 50094 km<sup>2</sup>. These districts



Methodology Flow chart

experience extreme climatic conditions characterized by high temperatures and low annual rainfall, making them ideal for studying vegetation and land use changes in arid environments. The geographical location of these districts places them within the Thar Desert, significantly influencing their ecological and environmental dynamics. The region's land use patterns are predominantly shaped by agricultural activities, urbanization, and natural desertification processes. Understanding the spatio-temporal changes in vegetation health and land use is crucial for sustainable land management and environmental conservation in these arid zones.

### **Objectives**

- (1) To Analyse Spatio-Temporal Land Use and Land Cover (LULC) Changes using Landsat 7 and 8 satellite data using ERDAS IMAGINE software and Conduct accuracy assessment to ensure the reliability of the result.
- (2) To Evaluate Vegetation Health and Density Using Normalized Difference Vegetation Index (NDVI) over the years 2001, 2010 and 2024 and correlating these changes with environmental factors and land management practices to provide insights into the ecological impacts of land use changes.

### **Database and Methodology**

For this study, Landsat-8 satellite images from May 2024, Landsat-7 satellite images from April 2010, and May 2001 were downloaded from the USGS Earth Explorer website (Manandhar et al., 2009). The blue, green, red, near-infrared, and short-wave infrared bands were utilized to generate LULC maps and various remote sensing indices. The methodology flowchart is presented in Fig-1. False-colour composite (FCC) imagery was employed for land use/land cover mapping (Hurni et al., 2005). Unsupervised image classification was performed using ERDAS IMAGINE software, applying the K-means classifier to categorize the images into 30 different LULC units (Anwar Khalid, 2019). These initial classes were subsequently reclassified into six categories: Water Bodies, Barren, Urban, Vegetation, Desert, and Hill. Remote sensing indices were calculated using ERDAS IMAGINE software. Finally, a correlation assessment was conducted between the LULC dynamics and NDVI for the years 2001, 2010, and 2024 (Walsh et al., 2001).

### **Result and Discussion**

#### **Landuse and Landcover Mapping and its Accuracy Assessment**

In the current study area, seven major LULC classes were identified: (1) Urban, (2) Vegetation, (3) Barren, (4) Desert, (5) Water Bodies, and (6) Hills.

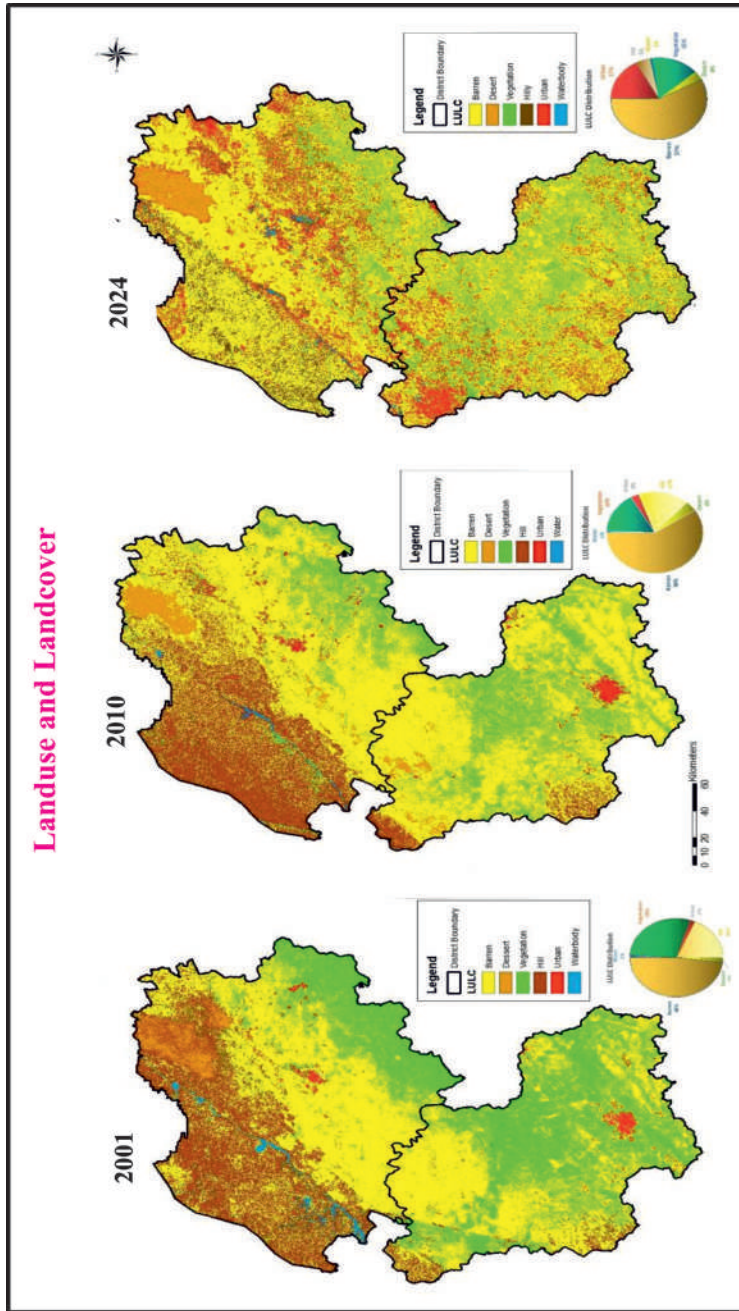


Fig. 1

These categories were confirmed using high-resolution satellite images from Google Earth. In 2001, Jodhpur and Bikaner exhibited a diverse LULC profile. The largest land cover type was barren land, occupying 2,542,950 hectares (48.02% of the total area). Vegetation was the second-largest LULC type, covering 1,517,827 hectares (28.66%). Hills accounted for 989,493 hectares (18.69%). Urban areas were relatively small, comprising 95,625.3 hectares (1.81%). Water bodies and desert areas were the smallest LULC types, covering 53,675.7 hectares (1.01%) and 95,656.3 hectares (1.81%), respectively. This distribution indicates a landscape predominantly characterized by natural land cover types with limited urban development and water resources. By 2010, significant changes in LULC had occurred. Barren land expanded to 3,139,190 hectares (59.28%), reflecting an increase of 596,240 hectares (11.26%), suggesting substantial land degradation or reduced vegetation cover. The area covered by vegetation decreased to 852,113 hectares (16.09%), marking a reduction of 665,714 hectares (12.57%). Hills saw a decrease to 910,544 hectares (17.20%), a reduction of 78,949 hectares (1.49%). Urban areas expanded to 150,810 hectares (2.85%), indicating a rise of 55,184.7 hectares (1.04%) and ongoing urbanization. Water bodies decreased significantly to 33,370.7 hectares (0.63%), marking a loss of 20,305 hectares (0.38%). Desert areas expanded to 209,309 hectares (3.95%), an increase of 113,652.7 hectares (2.15%). These changes highlight the significant impact of human activities, such as urbanization and deforestation, on the environment. By 2024, further significant changes in LULC were observed. Urban areas experienced dramatic expansion, reaching 912,403 hectares (17.23%), marking an increase of 761,593 hectares (14.38%) from 2010. This rapid urbanization likely exerted additional pressure on natural resources. Barren land slightly decreased to 3,051,700 hectares (57.63%), a reduction of 87,490 hectares (1.65%). Vegetation cover continued to decline, reaching 833,910 hectares (15.74%), a decrease of 18,203 hectares (0.34%). Hill areas underwent a significant decline, reaching 249,142 hectares (4.70%), a decrease of 661,402 hectares (12.49%). Water bodies recovered to 46,135.5 hectares (0.87%), an increase of 12,764.8 hectares (0.24%). Desert areas decreased slightly to 202,053 hectares (3.82%), a reduction of 7,256 hectares (0.14%).

The overall accuracy and Kappa coefficient provide important insights into the reliability of LULC classifications for Jodhpur and Bikaner over the years 2001, 2010, and 2024 (Foody, 2020). In 2001, the high overall accuracy of 90.48% and strong Kappa coefficient of 0.8889 indicated a highly reliable classification. However, by 2010, these metrics dropped to 80.00% and 0.6774, respectively,

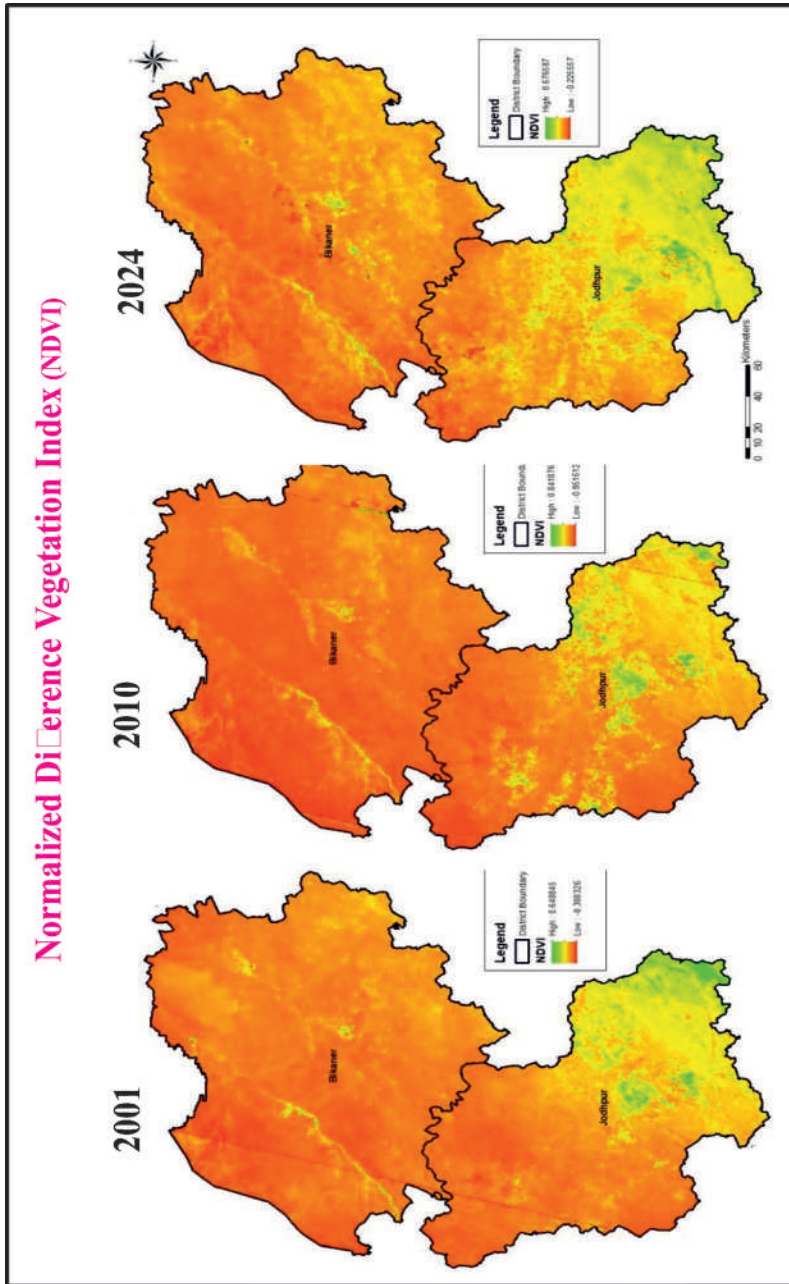


Fig. 2

reflecting increased complexity in LULC changes and classification challenges. By 2024, both metrics improved significantly, with overall accuracy reaching 93.33% and the Kappa coefficient at 0.8790, suggesting advancements in remote sensing technology and data processing techniques had enhanced classification reliability (Abdulraheem et al., 2023). These trends underscore the dynamic nature of LULC changes and the continuous need for improved classification methods to ensure accurate environmental monitoring and sustainable land management.

### **Remote sensing index- Normalized Difference Vegetation Index (NDVI)**

The Normalized Difference Vegetation Index (NDVI) widely used remote sensing index that measures vegetation health and density. It is calculated using red (RED) and near-infrared (NIR) bands of the electromagnetic spectrum (Forkel et al., 2013).

The following formula:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Note: Values of NDVI range from -1 to +1, with higher values indicating healthier and denser

### **Vegetation.**

In 2001 NDVI values ranged from a minimum of -0.388 to a maximum of 0.648. The mean value was 0.054 with a standard deviation of 0.024. The negative minimum value suggests the presence of non-vegetated surfaces. Examples include barren land or urban areas. These have low or negative NDVI values. The maximum value of 0.648 indicates regions with healthy. Dense vegetation. The mean NDVI value of 0.054 suggests that, on average area had relatively sparse vegetation. Standard deviation of 0.024 indicates moderate variability in vegetation cover across the study area. By 2010 NDVI values showed slight change. Minimum dropped to -0.95. Maximum decreased to 0.84. The mean NDVI value increased slightly to 0.061. The standard deviation increased to 0.028. A lower minimum NDVI value suggests an increase in non-vegetated or poorly vegetated areas. Possibly due to urbanization or land degradation. A maximum NDVI value of 0.84 still indicates areas of healthy vegetation. Although slightly lower than in 2001. Increased mean NDVI value suggests a slight overall improvement in vegetation health (Gandhi et al., 2015). Higher standard deviation reflects greater variability in vegetation cover.

In 2024 NDVI values show further changes. The minimum value increases to -0.225. The maximum decreases to 0.6. The mean rises to 0.137. The standard deviation increases to 0.029. The higher minimum NDVI value suggests a reduction in non-vegetated areas. This change may be attributed to reforestation or improved land management practices. The lower maximum NDVI value of 0.6 indicates the most vegetated areas are not as dense as in previous years. The increased mean NDVI value of 0.137 reflects an overall improvement in vegetation health. The slight increase in standard deviation to 0.029 indicates considerable variability in vegetation cover.

Table-2: NDVI Statistics

Statistics	2001	2010	2024
Minimum	-0.388	-0.95	-0.225
Maximum	0.648	0.84	0.6
Mean	0.054	0.061	0.137
Standard deviation	0.024	0.028	0.029

Source: Authors

## Conclusions

The analysis of land use and land cover (LULC) changes and NDVI in Jodhpur and Bikaner, Rajasthan, from 2001 to 2024 reveals significant environmental transformations, highlighting the complex interplay between human activities and natural processes in these regions. The most notable change over the study period has been rapid urban expansion, which has dramatically increased urban areas and exerted significant pressure on natural resources. This expansion has led to substantial reductions in forested areas, vegetation cover, and hill areas, while fluctuating water resources further underscore the adverse impacts of human activities and climatic factors. These findings point to the urgent need for sustainable land management practices that balance urban development with the conservation of natural ecosystems. The NDVI analysis, which measures vegetation health, reveals dynamic changes in vegetation cover over the years. In 2001, NDVI values indicated moderate vegetation cover with notable variability. By 2010, there was a slight improvement in overall vegetation health, but increased variability suggested ongoing changes in land use. By 2024, NDVI values showed a significant overall improvement in vegetation health; however, the densest vegetation areas were less prominent. This analysis underscores the need for sustainable practices to maintain

and enhance vegetation health, which is essential for ecological sustainability in the region. In conclusion, the analysis of LULC changes and NDVI highlights significant environmental dynamics in Jodhpur and Bikaner driven by rapid urbanization, deforestation, and other human activities. The study emphasizes the need for integrated sustainable land management approaches that balance development with conservation to preserve natural resources and ensure the ecological health of these regions.

## References

- Abdulraheem, M.I., Zhang, W., Li, S., Moshayedi, A.J., Farooque, A.A., Hu, J., 2023. Advancement of Remote Sensing for Soil Measurements and Applications: A Comprehensive Review. *Sustainability* 15, 15444. <https://doi.org/10.3390/su152115444>
- Anwar Khalid, K., 2019. Using unsupervised classification to determined land cover northren of Ninvah provianec by using Remote sensing Techniques. *J Phys Conf Ser* 1294, 092037. <https://doi.org/10.1088/1742-6596/1294/9/092037>
- Beg, K., Bhadra, B.K., Sharma, J.R., Punia, M.P., Chaurey, R., 2013. 18th Convention Special Volume, Jour. Ind. Geol. Cong.
- Ehsan, S., Kazem, D., 2013. Analysis of land use-land covers changes using normalized difference vegetation index (NDVI) differencing and classification methods. *Afr J Agric Res* 8, 4614–4622. <https://doi.org/10.5897/AJAR11.1825>
- Foody, G.M., 2020. Explaining the unsuitability of the kappa coefficient in the assessment and comparison of the accuracy of thematic maps obtained by image classification. *Remote Sens Environ* 239, 111630. <https://doi.org/10.1016/j.rse.2019.111630>
- Forkel, M., Carvalhais, N., Verbesselt, J., Mahecha, M.D., Neigh, C.S.R., Reichstein, M., 2013. Trend Change detection in NDVI time series: Effects of inter-annual variability and methodology. *Remote Sens (Basel)* 5, 2113–2144. <https://doi.org/10.3390/rs5052113>
- Gandhi, G.M., Parthiban, S., Thummalu, N., Christy, A., 2015. Ndvi: Vegetation Change Detection Using Remote Sensing and Gis – A Case Study of Vellore District. *Procedia Comput Sci* 57, 1199–1210. <https://doi.org/10.1016/j.procs.2015.07.415>
- Getahun, S., Yoseph, M., 2022. Land use land cover changes and its implication on ecotourism in hawassa city and its surroundings?. *Ukr J Ecol* 12. [https://doi.org/10.15421/2022\\_340](https://doi.org/10.15421/2022_340)
- Hurni, Hans, Tato, Kebede, Z., Gete, 2005. The Implications of Changes in Population, Land Use, and Land Management for Surface Runoff in the Upper Nile Basin Area of Ethiopia. [https://doi.org/10.1659/0276-4741\(2005\)025\[0147:TIOCIP\]2.0.CO;2](https://doi.org/10.1659/0276-4741(2005)025[0147:TIOCIP]2.0.CO;2) 25, 147–154. [https://doi.org/10.1659/0276-4741\(2005\)025](https://doi.org/10.1659/0276-4741(2005)025)
- Idrees, M.O., Omar, Dahir. M., Babalola, A., Ahmadu, Hussein. A., Yusuf, A., Lawal, F.O., 2022. Urban land use land cover mapping in tropical savannah using Landsat-8 derived normalized difference vegetation index (NDVI) threshold. *South African Journal of Geomatics* 11. <https://doi.org/10.4314/sajg.v11i1.8>
- Jomaa, I., Kheir, R.B., n.d. Options Méditerranéennes-Série B, no 46 Environmental Monitoring in the South-Eastern Mediterranean region using RS/GIS Techniques.

- Jothimani, M., Gunalan, J., Duraisamy, R., Abebe, A., 2021. Study the Relationship Between LULC, LST, NDVI, NDWI and NDBI in Greater Arba Minch Area, Rift Valley, Ethiopia. <https://doi.org/10.2991/ahis.k.210913.023>
- Kar, A., Garg, B.K., Singh, M.P., Kathju, S., n.d. TRENDS IN ARID ZONE RESEARCH IN INDIA.
- Lu, D., Li, G., Moran, E., Hetrick, S., 2013. Spatiotemporal analysis of land-use and land-cover change in the Brazilian Amazon. *Int J Remote Sens* 34, 5953–5978. <https://doi.org/10.1080/01431161.2013.802825>
- Manandhar, R., Odeh, I.O.A., Ancev, T., 2009. Improving the Accuracy of Land Use and Land Cover Classification of Landsat Data Using Post-Classification Enhancement. *Remote Sens (Basel)* 1, 330–344. <https://doi.org/10.3390/rs1030330>
- Mancino, G., Nolè, A., Ripullone, F., Ferrara, A., 2014. Landsat TM imagery and NDVI differencing to detect vegetation change: assessing natural forest expansion in Basilicata, southern Italy. *IForest* 7, 75–84. <https://doi.org/10.3832/ifor0909-007>
- Marudhara Academy, n.d.
- Özyavuz, M., Çankır, C.B., Üniversitesi, K., Salıcı, A., 2015. Determination of vegetation changes with NDVI method, Article in *Journal of Environmental Protection and Ecology*.
- Saharan, M.A., Vyas, N., Borana, S.L., Yadav, S.K., 2018. CLASSIFICATION AND ASSESSMENT OF THE LAND USE – LAND COVER CHANGES IN JODHPUR CITY USING REMOTE SENSING TECHNOLOGIES. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-5*, 767–771. <https://doi.org/10.5194/isprs-archives-XLII-5-767-2018>
- Walsh, S.J., Crawford, T.W., Welsh, W.F., Crews-Meyer, K.A., 2001. A multiscale analysis of LULC and NDVI variation in Nang Rong district, northeast Thailand. *Agric Ecosyst Environ* 85, 47–64. [https://doi.org/10.1016/S0167-8809\(01\)00202-X](https://doi.org/10.1016/S0167-8809(01)00202-X)

--Dr. Lalit Singh Jhala  
Assistant Professor  
Department of Geography  
Jai Narayan Vyas University  
Jodhpur (Rajasthan)

--Mr. Ashok Gehlot  
Research scholar  
Department of Geography  
Jai Narayan Vyas University  
Jodhpur (Rajasthan)

--Mr. Vivek Raj Singh Chauhan  
SRF Research scholar  
Department of Geography  
Jai Narayan Vyas University  
Jodhpur (Rajasthan)



## **NANOPARTICLES UNVEILED-HARNESSING THE POWER OF GROUNDNUT SHELLS**

Usha, C. and Nandini, N

### **Abstract**

Nanoparticles (NPs) are acclaimed for their unique properties, attracting attention across various sectors from medicine to electronics. However, conventional synthesis methods often entail toxic reagents, posing environmental risks. This paper explores green synthesis using groundnut shell waste, a rich source of biomass, for NP production. Employing advanced characterization techniques, including SEM-EDS, and FTIR analysis, the study unveils the structural and chemical attributes of the synthesized NPs. Moreover, it delves into their potential in catalysis, environmental remediation, and biomedical applications. Overall, this research contributes to the sustainable utilization of agricultural waste for the synthesis of value-added nanomaterials, thereby addressing both environmental and economic concerns.

### **Introduction**

The escalating environmental concerns and the dwindling reservoirs of natural resources have sparked a relentless pursuit of sustainable alternatives in material synthesis. Agricultural waste materials, often dismissed despite their abundance, offer a fertile ground for the development of eco-friendly and economically viable nanomaterials. Among these overlooked resources, groundnut shell, brimming with lignocellulosic biomass, emerges as a compelling prospect for nanoparticle synthesis. This study aims to uncover the structural, and morphological properties of nanoparticles derived from groundnut shell waste material, while also exploring their potential applications. Nanotechnology has introduced a new era across diverse sectors, capitalizing on the unique attributes of nanoparticles. Within this transformative landscape, the eco-friendly production of nanoparticles has emerged as a beacon of hope, offering a sustainable alternative to conventional chemical methods. This paper endeavors to provide a comprehensive study of nanoparticles synthesized through green routes, encompassing a spectrum of approaches including

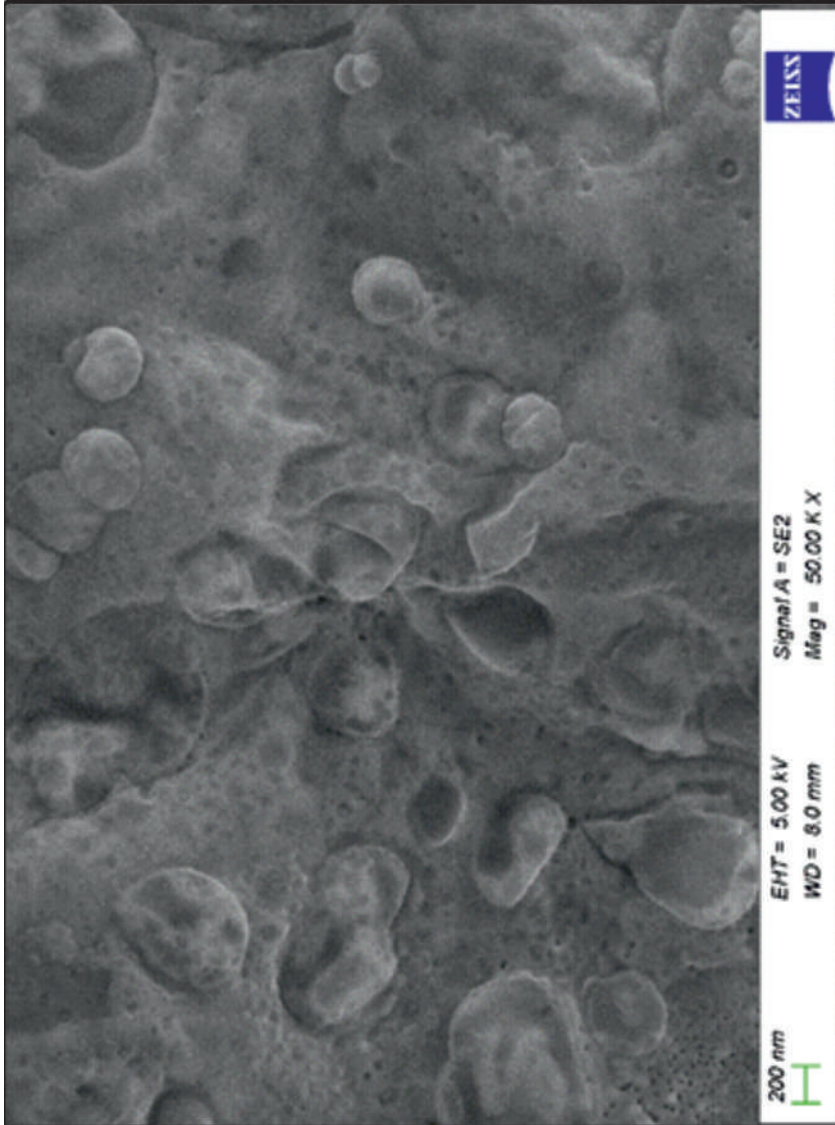


Photo: 1 - SEM Image of Biosynthesized Silver Nanoparticles of *A. hypogaea*

plant-mediated, and bio-inspired methods. Through this exploration, the inherent advantages of eco-friendly synthesis techniques are illuminated. Furthermore, the study navigates through the properties of nanoparticles synthesized via green routes, scrutinizing key parameters such as size, shape, and functionalization. The discussion extends beyond synthesis techniques to embrace the myriad applications of green-synthesized nanoparticles, spanning realms from medicine, and water treatment to agriculture. By unraveling the multifaceted utility of these nanoparticles, this study underscores the pivotal role of green synthesis in tailoring nanoparticles to meet diverse needs while simultaneously alleviating environmental burdens.

## Materials and Methodology

### Materials

#### **Arachis hypogaea**

**Family:** Leguminaceae

**Subfamily:** Papillonaceae

**Genus:** Arachis

**Species:** hypogaea

**Common Name:** Groundnut, Monkey nut

Groundnut shell is generally considered as agro-industrial waste and every year millions of tons of its quantity are left in the environment. Rich in lignin, these shells undergo slow degradation in a natural environment.

### Preparation of Green Synthesized Nanoparticles from A.hypogea shell

Silver nanoparticles were produced through a biological approach involving the conversion of silver ions ( $\text{Ag}^+$ ) by groundnut shell extract. Initially, groundnut shells were cleaned, powdered, and sieved to obtain a uniform extract. This extract served as both agents employed to reduce and stabilize during synthesis. Subsequently, a solution containing 1 mM silver nitrate was prepared. Mixing 5 ml of the groundnut shell extract with 95 ml of the silver nitrate solution, the resulting mixture was heated and stirred at  $80^\circ\text{C}$  for 20 minutes. The emergence of silver nanoparticles was signaled by a shift in color from a pale yellow hue to a brown shade, signifying the characteristic surface plasmon resonance of AgNPs.



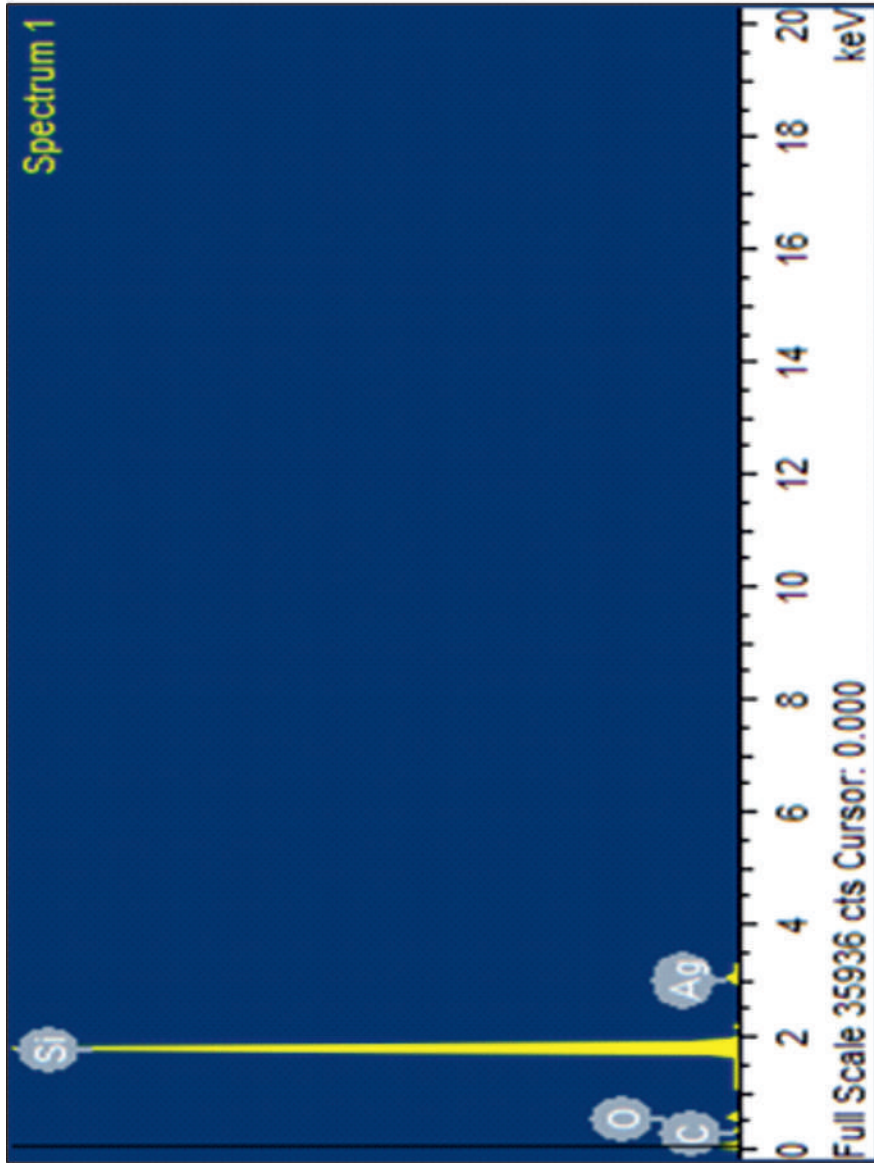


Photo: 2 - EDS Graph of Biosynthesized Silver Nanoparticles of *A.hypogaea*

## **Characterization of Bio-synthesized Silver Nanoparticles**

Groundnut shell waste material was collected, pretreated, and subjected to a synthesis process optimized for nanoparticle formation. The biologically synthesized silver nanoparticles were characterized using various spectroscopic, microscopic, and analytical techniques, including SEM-EDS, and FTIR.

### **Scanning Electron Microscopy (SEM)**

The morphology, size, and elemental composition of the silver nanoparticles were analyzed using SEM-EDS in the ULTRA ZEISS 55 GEMINI SERIES. The nanoparticle specimens were affixed onto aluminum stubs and underwent a gold sputter-coating process lasting 60 seconds to improve conductivity. Subsequently, they were examined using SEM at an accelerating voltage of 5.00 kV, and EDS analysis was performed to identify the elemental composition of the nanoparticles. EDS uses the electron beam of the SEM to interact with the sample and emits characteristic X-rays. These X-rays are then analyzed to identify the elements present in the material and quantify their concentrations.

### **Fourier-transform Infrared Spectroscopy (FTIR)**

FTIR analysis was performed utilizing a PERKIN ELMER FTIR SPECTROMETER FRONTIER to discern the functional groups responsible for stabilizing silver nanoparticles. A thin layer of the sample was applied onto a 1 cm × 1cm glass slide, followed by annealing in a muffle furnace at 300°C for 3 hours. The treated slide was then inserted into a sample holder for analysis. FTIR spectra of the nanoparticle powder were captured within the range of 400-4000 Cm<sup>-1</sup>. FTIR (Fourier Transform Infrared) spectroscopy stands as a versatile analytical tool, providing valuable insights into the organic composition and molecular structure of substances. By detecting characteristic absorption bands, FTIR spectra aid in identifying functional groups and bond types (e.g., C=O, C-H, O-H, N-H) within a sample. These bands represent the unique "fingerprint" of the material, facilitating the identification of specific chemical groups within molecules.

## **Results and Discussion**

The characterization results revealed the successful synthesis of nanoparticles from groundnut shell waste material. SEM-EDS is used to examine the morphology and elemental composition of materials at the micro- and nanoscale. SEM provides high-resolution images of sample surfaces, while EDS enables the identification and quantification of elements present in the sample (Photo-1).

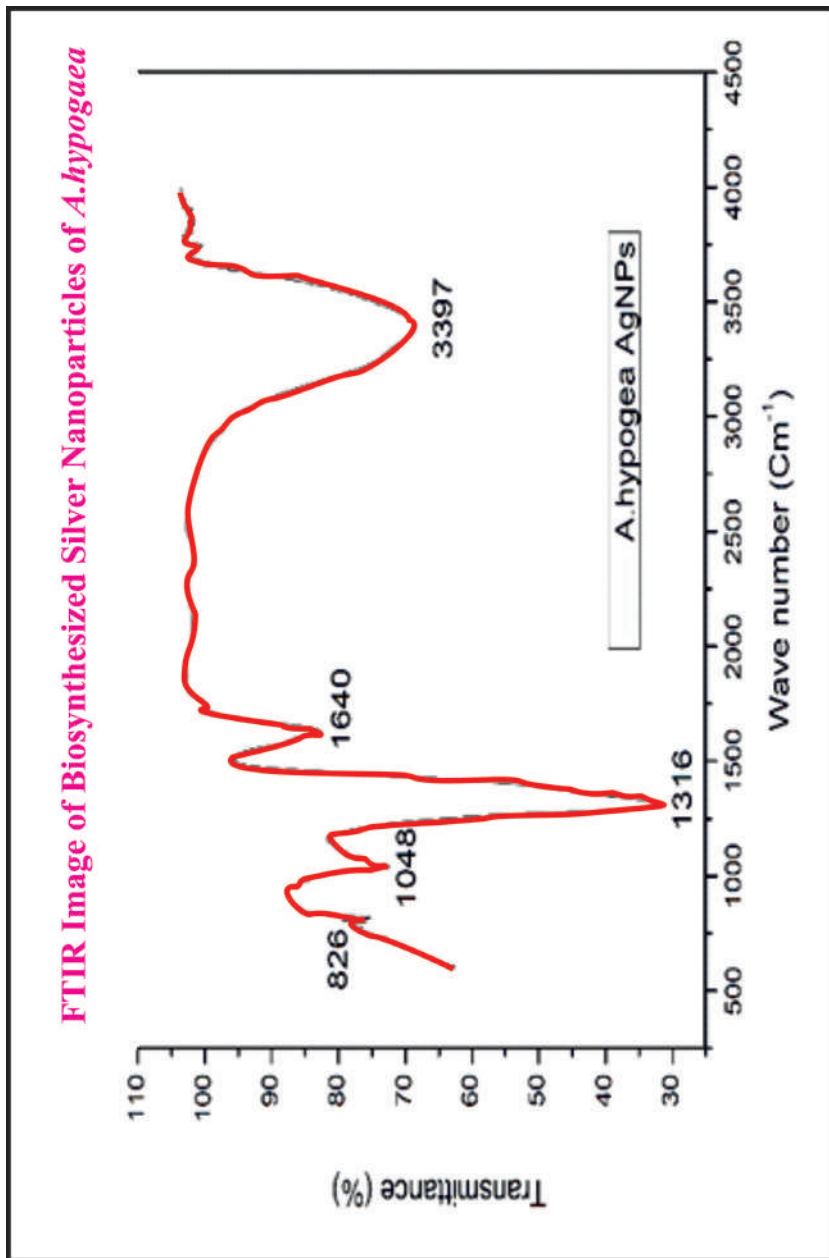


Fig. 1

FTIR analysis elucidated the existence of functional groups linked with Cellulose, hemicellulose, and lignin constituents of groundnut shells, which may contribute to the stabilization and surface modification of the nanoparticles.

### Scanning Electron Microscopy (SEM)

SEM-EDS, or scanning electron microscopy with energy-dispersive X-ray spectroscopy, is a powerful analytical technique used to examine the morphology and elemental composition of materials at the micro- and nanoscale. SEM provides high-resolution images of sample surfaces, while EDS enables the identification and quantification of elements present in the sample respectively. Fig-1 shows the SEM images of *A.hypogaea* silver nanoparticles in both images we can see spherical nanoparticles distributed evenly in the samples, with sizes varying between 100 to 300nm. Further, the surface is even and uniform with no defects. While EDS uses the electron beam of the SEM to interact with the sample and emits characteristic X-rays. These X-rays are then analyzed to ascertain the present elements in the material and quantify their concentrations. Photo-2 and Fig-1 shows the EDS graph of *A.hypogaea* silver nanoparticles and (Table-1) shows the EDS percentage of the *A.hypogaea* silver nanoparticles, the analysis confirmed the presence of silver nanoparticles in the samples, with an atomic percentage of 1.35% indicating the successful synthesis of AgNPs. The EDS percentage does not determine the elemental composition of the material precisely, as it mainly takes on the surface of the material. However, EDS gives a significant insight into the material composition.

Table-1: Elements Embedded in *A.hypogaea* Silver Nanoparticles with Percent

Element	Weight%	Atomic%
C K	10.42	19.84
N K	6.07	9.9
O K	10.01	14.3
Si K	66.9	54.45
Cl K	0.25	0.16
Ag L	6.36	1.35
Total	100	100

Source: Authors

### Fourier-Transform Infrared Spectroscopy (FTIR)

*A.hypogaea* silver nanoparticles are subjected to FTIR in the range of 400-

4000  $\text{Cm}^{-1}$ . The spectra produced by FTIR show 5 characteristic bands at 826, 1048, 1316, 1640, and 3397  $\text{Cm}^{-1}$ .

- (1) The band at 826  $\text{Cm}^{-1}$  assigned to stretching vibration suggests the presence of aromatic compounds or alkenes with C-H bond, which could originate from the plant extracts used in the synthesis process.
- (2) The band at 1048  $\text{Cm}^{-1}$  assigned stretching vibration indicates the presence of carbohydrates with C-O bond, possibly from the reducing agents in the plant extracts, contributing to stabilizing silver nanoparticles.
- (3) The band at 1316  $\text{Cm}^{-1}$  assigned bending vibration may indicate the presence of aliphatic compounds with CH<sub>3</sub> or CH<sub>2</sub> groups, potentially from the stabilizing agents or capping agents involved in the synthesis.
- (4) The band at 1640  $\text{Cm}^{-1}$  assigned stretching vibration indicates carbonyl groups with C=O, which could be attributed to organic compounds from the plant extracts or potential surface functionalization of the silver nanoparticles.

The band at 3397  $\text{Cm}^{-1}$  with broad stretching vibration suggests the presence of hydroxyl groups with O-H bond, which could arise from the stabilizing agents or water molecules adsorbed on the surface of the nanoparticles.

## **Conclusion**

This study presents a comprehensive characterization of nanoparticles synthesized from groundnut shell waste material. The results underscore the feasibility of utilizing agricultural waste for the sustainable production of value-added nanomaterials. The synthesized nanoparticles exhibit promising properties for applications in various fields including water treatment, environmental remediation, and biomedicine. Future research endeavors may focus on optimizing the synthesis process, elucidating the mechanisms underlying nanoparticle formation, and exploring additional applications to fully harness the potential of groundnut shell-derived nanoparticles. Overall, this work contributes to the advancement of green nanotechnology and the utilization of renewable resources for sustainable development. In conclusion, this study offers a comprehensive characterization of both biologically synthesized silver nanoparticles derived from groundnut shell waste material. Through SEM-EDS, and FTIR analysis, we have gained valuable insights into the morphology, elemental composition, crystalline nature, and optical properties of these nanoparticles. Our findings highlight the potential of eco-synthesized silver nanoparticles for various technological applications, while also emphasizing the feasibility of utilizing agricultural waste

for sustainable nanomaterial production. Moving forward, it is crucial to continue advancing our understanding in this field. Future research efforts should focus on optimizing synthesis processes, elucidating underlying formation mechanisms, and exploring additional applications to fully harness the potential of these eco-friendly nanoparticles. By this, we can contribute to the advancement of green nanotechnology and the sustainable utilization of renewable resources, ensuring a brighter future for both technology and the environment.

## References

- Adur, A. J., Nandini. N. 2020. Activated Carbon Impregnated with Silver Nanoparticles for Remediation of Wastewater. *International Journal of Commerce, Arts, and Science*, 11(4), 52-58. ISSN 2319-9202.
- Adur, A. J., Nandini. N. 2019. Antibacterial Activity of Biosynthesized Nanoparticles using Tamarind Shell Extract. *Journal of Emerging Technologies and Innovative Research (JETIR)*, 6(5), 652-673. [www.jetir.org](http://www.jetir.org) (ISSN-2349-5162)
- Bar, H., Bhui, D. K., & Sahoo, G. P. 2009. Green synthesis of silver nanoparticles using latex of *Jatropha curcas*. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 339(1-3), 134-139
- Huang, H., Li, L., Si, Y., Zhang, J., Gan, L., Yan, J., & Zhuo, S. 2017. Green synthesis of Ag/AgCl nanoparticles and their visible light photocatalytic activities for the degradation of methyl orange. *Materials Letters*, 198, 120-123.
- Iravani, S. 2011. Green synthesis of metal nanoparticles using plants. *Green Chemistry*, 13(10), 2638-2650.
- Jai Kumar, B., Tejas, M. K., Sumanth Kumar, D., Naveen Kumar, K. B., Vinutha, K.V., Mahesh, H.M. 2020. Natural dye-sensitized solar cells using Lawsone pigment of *Lawsonia inermis* (henna leaves) as sensitizers, *International Journal of Advances in Engineering and Management (IJAEM)*, 2(1), 34-40. DOI: 10.35629/5252-45122323
- Khan, M., Khan, M., Adil, S. F., Tahir, M. N., Tremel, W., & Alkathlan, H. Z. (2015). Green synthesis of silver nanoparticles mediated by *Pulicaria glutinosa* extract. *International Journal of Nanomedicine*, 10, 87-97.
- Krishnaraj, C., Jagan, E. G., Rajasekar, S., Selvakumar, P., Kalaichelvan, P. T., & Mohan, N. 2010. Synthesis of silver nanoparticles using *Acalypha indica* leaf extracts and its antibacterial activity against water-borne pathogens. *Colloids and Surfaces B: Biointerfaces*, 76(1), 50-56.
- Mittal, A. K., Chisti, Y., & Banerjee, U. C. 2013. Synthesis of metallic nanoparticles using plant extracts. *Biotechnology Advances*, 31(2), 346-356.
- Pham Anh Duc, P. Dharanipriya, Bharath Kumar Velmurugan, M. Shanmugavadivu, 2019, Groundnut shell -a beneficial bio-waste, *Biocatalysis, and Agricultural Biotechnology*, Volume 20, ISSN 1878-8181, <https://doi.org/10.1016/j.cbab.2019.101206>. (<https://www.sciencedirect.com/science/article/pii/S1878818119305560>)
- Rai, M., Yadav, A., & Gade, A. 2009. Silver nanoparticles as a new generation of antimicrobials. *Biotechnology Advances*, 27(1), 76-83.
- Shankar, S. S., Ahmad, A., Sastry, M., & Singh. A. 2003. Bioreduction of chloroaurate ions by geranium leaves and its endophytic fungus yields gold nanoparticles of different shapes. *Journal of Materials Chemistry*, 13(7), 1822-1826.

Yang, J., Kim, E., & Son, H. Y. 2014. Fabrication of silver nanoparticles with highly antimicrobial activities using capsicum annum extract. *Journal of Food and Drug Analysis*, 22(2), 226-233.

Zhu, H., Du, M., Zhang, B., & Zhang, H. 2015. Biosynthesis of gold nanoparticles using chloroplasts. *International Journal of Nanomedicine*, 10, 5031-5043.

--Usha. C  
Department of Environmental Science  
Bangalore University, Bangalore  
(Karnataka)

--Nandini. N  
Department of Environmental Science  
Bangalore University, Bangalore  
(Karnataka)



## **PRECARITY OF NATURAL RESOURCE-BASED LIVELIHOODS-A STUDY OF THE VADDERA COMMUNITY, TELANGANA STATE**

Parupally Anjaneyulu and Sankineni Laxman Rao

### **Abstract**

The Vaddera community of Telangana continues to be among the poorest occupational groups in the State. Officially classified as a backward caste, the community's traditional occupation has been stone work at stone reserves such as quarries and hillocks. The work involves quarrying, cutting and shaping stone for different purposes. In the recent past they have diversified into digging and other construction related activities in both urban and rural areas. This article draws on primary data collected from a representative sample of 150 Vaddera households spread across Telangana state. The community continues to rely on traditional work which is the primary source of household income. The community is unable to diversify into more gainful activities on account of poverty, low education levels, and seasonal migration. They eke out a precarious living from the traditional occupation which has become unreliable owing to a variety of factors such as the use of modern technology by contractors in the form of earth-moving machinery, decreased access to quarries and stone reserves due to the regulatory policies of the government and the financial incapacity to invest in machinery. The paper concludes with a set of implementable policy recommendations such as the need for improving civic infrastructure in the Vaddera localities, more inclusive social protection interventions, financial support for mechanising their work, preferential treatment in education and capacity building to facilitate livelihood diversification.

### **Introduction**

From a livelihood perspective, mineral reserves—both subterranean and surface—are among the most important natural resources sustaining life and contributing to livelihoods and economic growth. But over the past couple of decades, the nature of these resources has undergone a sea change in terms of their overexploitation with implications for sustainability; how they are governed; and their dependability for those who derive their livelihoods from them. A large number

of social groupings and civilizations, including tribes and traditional occupational communities, depend on natural resources for their livelihood. All resources were freely available to traditional occupational communities for all of recorded history. In an effort to raise taxes, the state and its agencies started to impose access restrictions as a result of new technological advancements and population increase. This had a negative impact on the lives of the communities that depend on natural resources. The Vaddera Community stands out among the adversely impacted communities. With regard to the origins of the Vaddera community, Edger claims that the word Vodde or Odde was derived from the Sanskrit word Odhra. A legend about the Oddes or Vadderas is told in the book "Castes and Tribes in South India" (Edger 1909). The Vaddera community arose during the Eastern Ganga Dynasty, which later evolved into the Gajapathi Kingdom (Odisha region). Later, they moved to southern states such as Telangana, Andhra Pradesh, Tamil Nadu, and Karnataka, as well as to western states such as Maharashtra and Gujarat. According Stuart (1894), the Oddes or Voddas worked in quarrying stones, sinking wells, building tank bunds, and other tasks. According to the 1871 Census, they were also involved in levelling gravel for laying roads (for the Public Works Department and Railways); water management works such as deepening of irrigation tanks, removal of clay from tanks and canals; agricultural operations such as bunding and re-bunding (to retain water in a specific place) on cultivable lands.

### **Study Region**

Telangana State has a population of 3.5 crore living in its 1,12,077 sq. km. area. Andhra Pradesh borders on the south and east, Karnataka borders it on the west, and Maharashtra and Chhattisgarh border it on the north. The State is home to all the three categories of historically disadvantaged communities among others, that is, the Backward Castes (BCs), Scheduled Castes, and Scheduled Tribes. The Vaddera community is classified as BC-A category. The Vadderas have been one of the most marginalised communities in Telangana – socially, economically and politically. It is also a natural resource-dependent community. It can be divided into two sub-groups based on the type of work they are engaged in, namely Banda Vaddera (stone work) and Matti Vaddera (earth work). Banda Vadderas work as stone cutters, whereas Matti Vadderas excavate dug wells and desilt tanks. However, historically stone work has been more widespread and a predominant activity among the Vadderas who depended on the resources such as hillocks or rock beds for their livelihood. On account of the state takeover of the resources as a source of revenue generation, the vulnerable Vaddera community is denied free

access to hillocks and other stone reserves. For generations, the Vaddera population of Telangana has been involved in traditional construction-related occupations in both rural and urban settings. However, for a variety of reasons, some Vadderas have stopped participating in the traditional activity or have remained unemployed in recent years. In India, an estimated 40 lakh Vaddera people live in various states where they are confronted with similar challenges and vulnerabilities as other numerically small and poor occupational castes which prevent them from moving up the socio-economic ladder. According to data shared by community representatives, the community is spread across the Telangana State and has a total population of 4 lakhs. The highest number of Vadderas are found in the former district of Rangareddy, followed by Mahabubnagar, Nalgonda, and Karimnagar. Nizamabad and Warangal districts account for more than 10 percent of the Vadderas, while each of Medak, Khammam, Adilabad and Hyderabad districts have less than 7 percent of the Vaddera population. The community is known by different names such as Vaddi, Vadde Raju, or Vadde Rajulu, Oddera, Oddilu or Vaddelu, and Vadde or Odde.

### **Objectives**

- (1) To assess the socio-economic status of the Vadderas in Telangana
- (2) To map the natural resource sites relied upon by the Vadderas and examine public policies that restrict access to mineral resources.
- (3) To assess the constraints and opportunities associated with natural resource-based livelihoods
- (4) To make actionable recommendations to enhance the livelihoods of the community.

### **Material and Methodology**

The research examines the socio-economic conditions and the livelihood challenges confronting the Vaddera community in Telangana State. The livelihoods of the Vaddera community in general and in Telangana in particular remain unexplored. Telangana's northern, central, and southern regions were included in the study to ensure that all major geographical areas of the State were fairly represented in the district selection process. Considering the recommendations and comments from community representatives regarding the distribution of the Vaddera population, the districts Karimnagar, Nizamabad, Nalgonda, Rangareddy, Mahabubnagar, and Hyderabad were chosen for the study. Ten representative mandals were selected from the six sample districts. And one village/urban ward was selected from each

of the sample mandals employing the same methodology. A total of 150 Vaddera households were covered by selecting 15 households from each site. A mixed method approach was employed in which a comprehensive questionnaire was administered to collect quantitative data. The Vaddera households in the selected villages and urban areas that are engaged in the traditional activities were selected using a purposive sampling technique. A standardized questionnaire was used to gather primary household data. Furthermore, three respondents from caste cooperatives/associations or community elders were chosen for strategic interviews from each district. One Focus Group Discussion (FGD) with a representative sample of the population was held in each chosen village or metropolitan locality.

## **Results and Discussion**

### **Socio-economic Conditions**

Traditional occupation and skills, including stonework, refer to methods, skills, and "technologies" derived from indigenous and occupational activities and practises that are pursued even today despite rapid advances on various fronts. For generations, the Vaddera population of Telangana is involved in the traditional construction-related occupations in both rural and urban settings. However, for a variety of reasons, some Vadders have stopped participating in the traditional activity or have remained unemployed in recent years. To evaluate the challenges and opportunities associated with traditional livelihoods, a thorough understanding of the community's socio-economic status is required. The study covered a total 150 households from both rural (105 households, comprising 70 percent of the sample) and urban (45 households, making up 30 percent of the sample) areas. The total population of the sample is 656. Among them, 208 are in urban areas and 448 are in rural areas. As for gender, 341 (52 percent) are males and 315 (48 percent) are females and the household size is 4.3. The sex ratio is 1083 but rural areas have better sex ratios than urban areas. Almost all the households reported to be following the Hindu tradition, who believe in Shavism and offer prayers to the local deities. Historically, the community members generally resided in close proximity to their work sites such as quarries, hills and brick kilns. As a result, their houses were poorly-built and "temporary" in nature and bereft of basic amenities such as drinking water, toilets, electricity and road connectivity. The study found that 86percent of the households live in own houses and the rest reside in rented houses. Among all houses, only one-fourth (26 percent) are pucca houses and nearly 60 percent of them live in semi-pucca houses. While another one-sixth (16 percent)

dwells in kutcha houses. Nearly two-thirds (65 percent) of households have access to running water and 70 percent have a toilet facility. More than a third (37 percent) of households are connected to the sewerage system, while 93 percent have access to an LPG connection. However, nearly a tenth still rely on firewood or kerosene. In the study areas, nearly one-third (32 percent) of households reported owning agricultural land, with the average holding being one acre and the maximum being five acres. And 60 percent of the holdings are rain-dependent. Furthermore, one-fourth of them rely on unreliable surface water. Bore wells are only found in 6 percent of households. Only a few households keep livestock. The community of Vaddera has a 64% literacy rate. The majority of the population (28%) completed their education up to the tenth grade. Of them, less than one-fifth (17%) completed their primary education, and only 3.7% of them received a diploma. The percentage of post-graduates is far lower at less than 1%. 10% of pupils in the town drop out before finishing the tenth grade, representing a relatively high dropout rate. Because of migration, this rate is higher among earth workers. Results pertaining to work participation status (for the 15–65 age range) reveal that traditional occupations, which are pursued by about 90% of the workforce, make up by far the most important primary occupation. About 70 percent of those in secondary occupations—which only 30% of respondents reported having—work as labourers in agriculture. Just 20% of them indicated that farming was their secondary activity. The average landholding of the Vaddera households, 68 percent of them being landless, is barely one acre, indicating an extremely low level of agricultural land ownership. Furthermore, the majority of landed households lack access to dependable irrigation sources.

### **Traditional Occupation of Stonework**

Vadders' livelihood status is currently precarious and vulnerable, comparable to the state's poorest communities. Traditional or stone work is available between 150 and 200 days per year in both rural and urban areas. The study found extremely low level of white-collar employment among the community. The study found that two-thirds of the population is of working age (15-59) and the work participation is relatively high, with the workforce accounting for 52 percent of the total population and the remainder engaged in education (35 percent); 3 percent are non-working members due to old age; 10 percent of the able population belongs to non-working category; and more importunately, 90 percent of the workforce is employed in traditional activities. Of the 92 stonework sample households, 20 are from urban and the remaining 72 represent rural areas. Nearly all households (96 percent)

are engaged in rock blasting and rock cutting and only 4 percent households are engaged in contract works; and on average, two workers are engaged in stone related activities from each household. It is important to note that most of the respondents work at quarries that are owned by contractors. There are no community members who work as quarry contractors, suggesting that the community is far from achieving upward mobility in their own traditional domain. With respect to the seasonality of stonework, two-thirds (66 percent) of the households reported that it is generally available throughout the year. The remainder (34 percent) said that the work is seasonal or irregular. With respect to women's participation, unlike the earthwork households, participation of women is higher (70 percent) in the stonework category. Women are typically engaged in activities such as stone or material lifting and loading; and the rest of the women are involved in breaking stone into gravel, known as Kankara which is used in construction sector. Quarry and building contractors give priority to labour from the Vaddera community due to their traditional skills in the sector.

### **Types of Products**

Stoneworkers from the Vaddera community produce six types of products: gravel, square blocks, fencing pillars, marble, granite tiles, and irregular rocks. A total 80 percent of stonework households produce gravel and square blocks. In contrast, only rural households reported the remaining four products, but their proportions are relatively low. In urban areas, the proportion of households producing gravel and square blocks is slightly higher than in rural areas. The Vadder's product lines indicate that they primarily serve the construction industry. More than half (53 percent) of stoneworkers market their products on their own, which is significantly higher (72 percent) in urban areas, and 40 percent said that buyers come to the site to collect the material. Only two percent rely on intermediaries or agents to supply products to buyers. The stone products are marketed both within the state and in neighbouring states such as Karnataka.

### **Wage Rates, Household Incomes and Expenditure**

The study reveals that, daily wage rate ranges from Rs 150 to Rs 700. When the overall wage rate is considered, more than half (52 percent) of the Vadder's are paid Rs 350 or less per day and this proportion is much higher in rural areas (64 percent) indicating that urban wage rates are significantly higher. Nearly a fourth of them earn between Rs 350 and to Rs 400; again, urban workers earn higher wages in this category as well. Another 15 percent of them get between Rs 400 and Rs 500.

By contrast, only 10 percent of the workers fall under the highest wage bracket of more than Rs 500 a day.

Table-1: Wage Rates Per Day for Stonework Households by Locations

Wage Category (Rs)	Urban (%)	Rural (%)	All (%)
<350	53.3	77.8	73.6
350-400	13.3	6.9	8.0
400-500	33.3	11.1	14.9
>500	0.0	4.2	3.4
Total	15 (100)	72 (100)	88 (100)
Mean wage (in Rs)	343	284	294
Minimum wage (in Rs)	150	150	150
Maximum wage (in Rs)	500	700	700

Source: Primary data

### Household Incomes

Regarding household incomes, the annual mean household income is Rs 1, 34,837. The study found that the Vaddera households spend relatively high amounts on food and ceremonial and festive occasions, which results in a low investment in human development areas such as health and education. As per the study findings, non-traditional activities generate higher returns for stonework households. Traditional activities account for 76 percent of household income for stonework households; this amply demonstrates the critical importance of traditional work for the stonework Vadders.

Table-2: Stonework Households' Annual Mean Incomes (in Rs)

Household annual mean income (Rs)	All
Primary occupation	121065
Secondary occupation	13772
Traditional Occupations	102152
Share of traditional occupation income in total HH income (percent)	76
Total HH income	134837

Source: Primary data



Fig. 1

## **Stone Sites**

In general, the dependence of Matti Vadderas on natural resources is very low as they are predominantly engaged in digging, excavating and construction-related work, by stark contrast, the Banda Vadderas almost exclusively depend on stone reserves and hillocks. Telangana has rich mineral resources. Mineral deposits of national significance, according to the Mining and Geology Department of Government of Telangana; these include limestone, barites, and coal, gold, diamonds, and dimension stones. The granite-based dimensional stone industry in Telangana has enormous potential. The Archaean Proterozoic granite-gneiss terrain, which accounts for more than 60 percent of the State, is a veritable treasure trove of colourful rocks. In addition to the primary minerals, there are additional granite resources in Peddapalli, Rajanna, Siddipet, Jangaon, and Nizamabad districts that produce significant amounts of single or multicoloured granite based on the availability of minerals. Some districts have low level of granite resources, such as Komaram Bheem, Karimnagar, Warangal, Bhadradri, Khammam, Suryapet, and western section districts like Sangareddy, Vikarabad, Medak, Medchal and Hyderabad. The State Government has granted 370 quarry leases to various companies between 2014 and 2019 (Fig.1).

Over 150 companies have been granted permits to excavate the resource in 2018, which is the highest number thus far. The study finds that in Jaggasagar, Pomal and Rajaram villages, the community members are unable to exploit the nearby hillocks and other stone sites and some of them commute for about 8 kms to access stone sites and make stone products-due to the enforcement of GOs stated earlier. Further, land owners of some villages such as Pomal and Jaggasagar do not allow the Vadderas to access stone deposits on their lands. This is partly due to the high demand for the finished stone products used in the construction sector. In Malkapur village there are more than 12 quarries which provide employment to some 50 people. But the skilled and educated Vaddera youth (polytechnic diplomas) are still engaged in low-paid jobs. When asked about the reasons the youth reported that they need special training on the use of modern tools and techniques in the field—such as stone blasting, cutting and making different products. The vast majority of the Vadderas in Manikeshwari Nagar, Devender Goud Nagar, Jaggasagar, Pomal, Rajaram, and Malkapur locations are involved in stone-related work. During interactions with them, they discussed a variety of barriers to accessing natural resources, raw materials and employment opportunities. In Devendar Goud Nagar the community members reported that certain Government orders

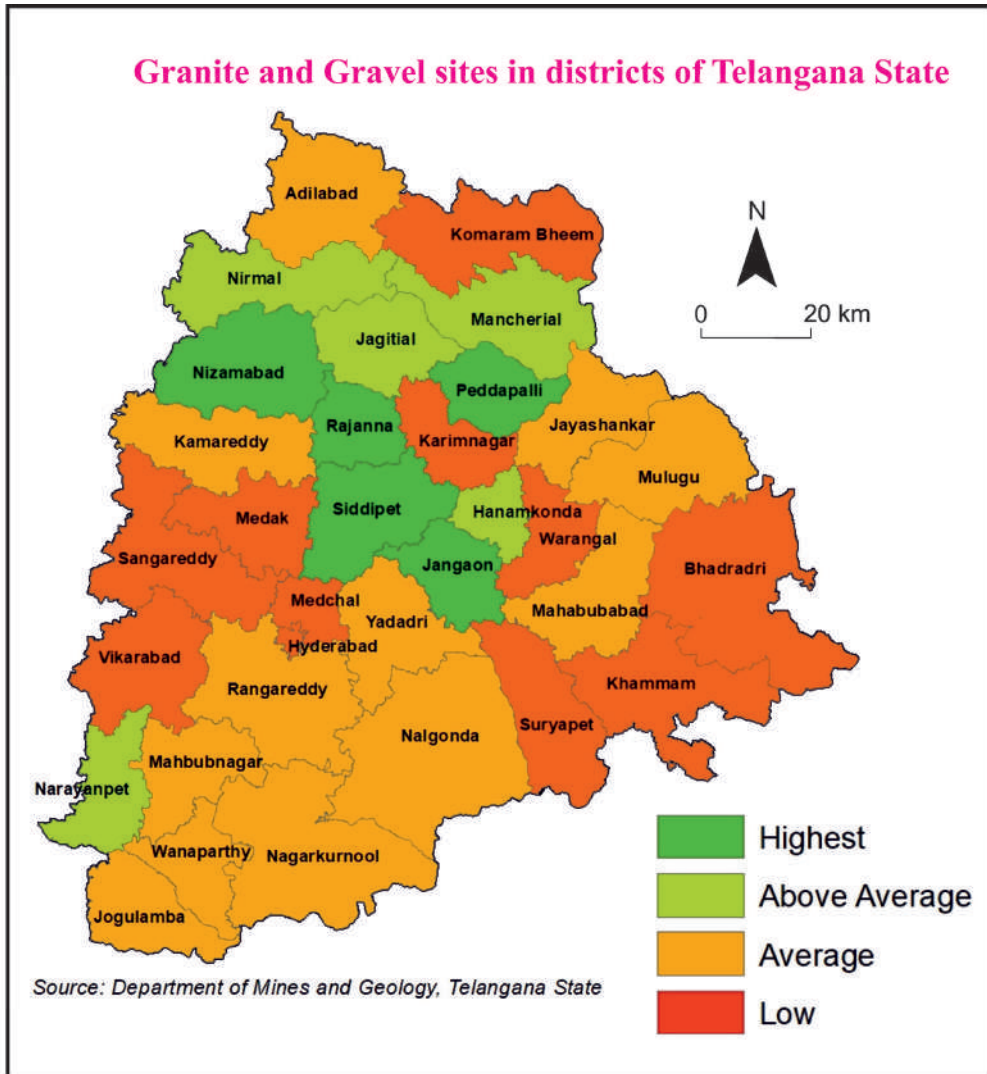


Fig. 2

and policies impede their hereditary occupations. They claim that the Revenue and Forest Departments, as well as the HMDA (Hyderabad Metropolitan Development Authority), refuse to allow them access the nearby hillocks (Chennapuram near Jawahar Nagar Municipality) on the grounds that rock blasting disturbs local residents and has negative environmental consequences (Fig. 2). A similar situation was reported from Jaggasagar Vaddera Colony.

### **Modern Machinery**

Stone reserves and hillocks are a prerequisite for sustaining traditional stonework operations. Only six of the ten research sites have quarry access. Since construction is a location-based industry, the Vadderas either commute or travel to work sites on a seasonal basis. The Vadderas make a meagre living through their traditional activities due to insufficient and unreliable opportunities in the respective sectors. Furthermore, migration for work increases their vulnerability by exposing them to a variety of risks and deprivations. All of the sample households agreed that modern technology like proclainers, JCBs, compressors, crushers, blasting material, tipper, and tractors had a negative impact on their livelihoods. Only five percent of the Vaddera households have modern machinery or tools related to their traditional occupation. As a result, the community anticipates government support in the form of modern equipment or financial assistance to purchase them.

### **Government Policies**

The granite-based rock sites are crucial for sustaining the livelihoods of the Vaddera community in the state. It is pertinent here to mention that certain public policies in the form of Government Orders (GOs) such as G.O. No. 37 of 2015, as well as the G.O. No. 48 of 2017 restrict the access to stone reserves and sites by creating barriers for the Vadderas and preventing them from continuing their traditional livelihoods. The said policies which restrict free access to mines and mineral resources are justified in the name of mobilising the much-needed revenues to foster the growth of State economy. As a result, a majority of Vadderas lost their jobs and began working in non-traditional activities such as wage labour in construction and agriculture sectors, while others remained unemployed. Because of insufficient and uncertain opportunities, the Vadderas make a precarious living through traditional work. The community is unable to automate or mechanise their activities owing to financial incapacity and the absence of financial support from the State Government.

The policies of the State Government governing the exploitation of mineral resources have had an adverse impact on the livelihoods of the Vadderas. To illustrate, quarries (the predominant livelihood source for stoneworkers) in the State are leased out to the successful bidders through auctions conducted by the Department of Mines and Geology. The bidding in the auction requires pre-qualifications and monetary deposits. But the Vadderas in general have neither the qualifications nor the financial resources to participate in the bidding process. Although some quarries are allotted to Vaddera societies free of rent or royalty, the number is woefully inadequate for the Vadderas.

### **Migration**

When it comes to the consequences of government restrictions, one can see migration and school dropouts as the most visible signs of adverse impacts in the study areas. Due to government restrictions, widespread seasonal migration has been taking place since the 1980s. In recent times, there has been a significant increase in the number of Vadderas choosing Maharashtra and Hyderabad as their destinations. Regarding the incidence of dropouts, a majority of the male migrant workers reported that their wives also join them in migration. The children go to school in the village under the guardianship of the elders. The study found that 10 percent of the Vaddera students dropped out of school before finishing 10th grade. Girls are more likely to be affected. They attribute school dropouts to the following key factors: a lack of adequate parental support and encouragement; poverty; a lack of access to high schools and colleges from their home towns; and a lack of reliable and affordable transportation facilities. Migrant members of the community conveyed their concerns about low wages they are paid at the destinations: the mean wage of is Rs 425 per day. The minimum and maximum rates paid are Rs 350 and Rs 500 respectively.

### **Conclusion**

The Vadderas in study districts as well as in the State as whole are spread thinly, making up only one percent of the population of the State. This drastically reduces the community's political leverage which is required to put pressure on the government agencies to influence policies. Moreover, the following findings related to the socio-economic status of the community are worth noting: Insufficient living space and low-quality housing; toilets without running water or with insufficient running water facilities; insufficient cultivable land and assured irrigation; landlessness and

reliance on wage income to supplement household income; increased expenditure on food, education, health, and clothing; unaffordability of occupation-related equipment; low income; low levels of education; impact of modern technology or machineries; low educational and knowledge levels inhibiting them from participating in government bidding process; inadequate allocation of quarries and a lack of dumping yards.

The major recommendations are, namely, (1) Reviewing and revising regulatory policies such as G.O. Nos. 38 and 48 to provide better access to quarries and stone sites (2) Dumping yards need to be allocated in both urban and rural areas (3) Financial support, skill development, and technology upgradation are imperative for improving the community's livelihoods (4) There is a need for innovative insurance policies and social security benefits for the community (5) Regarding quarry bidding, the EMD (Earnest Money Deposit) requirement need to be waived for the Vaddera civil contractors up to Rs 10 crore bid amount (6) The use of crushed stone or stone sand—a byproduct stone work undertaken by the community needs to be promoted by the government in civil works.

## References

- Abbe Dubois J.A. (1906): "Hindu Manners, Customs and Ceremonies" 3rd Edition, Oxford at the Clarendon Press.
- Edgar Thurston (1909): "Castes and Tribes of Southern India", Volume V, M-P, Government Press, Madras
- Government of Telangana (2016): Industries and Commerce (Mines-I) Department. G.O.Ms.No.37, Dated: 26-07-2016. <https://mines.telangana.gov.in/MinesAndGeology/Documents/GO's/GENERAL%20GO's%2037.PDF>
- Government of Telangana (2018): Rules - Mines & Quarries – The Telangana State Minor Mineral Concession Rules, GOMsNo\_48 [https://mines.telangana.gov.in/MinesAndGeology/Documents/Rules/GOMsNo\\_48.pdf](https://mines.telangana.gov.in/MinesAndGeology/Documents/Rules/GOMsNo_48.pdf)
- Gulam Ahmed Khan (1931): Census of India reports, Volume XXIII, H.E.H the Nizams Dominions (Hyderabad State), Part II - Tables, Printed by the Government Central Press, Hyderabad-Deccan <https://censusindia.gov.in/census.website/> <https://mines.telangana.gov.in/MinesAndGeology/Views/Index.aspx>
- Idate B R - National Commission for DNT/NT/SNT report (2017): "Denotified Tribes Nomadic and Semi-Nomadic Tribes in India" published by Ministry of Social Justice & Empowerment, Govt of India, New Delhi
- K.S. Singh (2003): People of India – Andhra Pradesh, Volume XIII, Part One, Anthropological Survey of India, East-West Press Pvt Ltd, New Delhi <https://www.telangana.gov.in/>
- Mirza Mehdy Khan (1891): Census of India, Volume XXIII. HIS Highness the Nizams Dominions, Part II, Printed at the Advocate of India Steam Press, Bombay

Robinson, Elizabeth J.Z. (2016): Resource-Dependent Livelihoods and the Natural Resource Base, Published in Annual Review of Resource Economics journal; V-8, No-1; pages -281-301

Stuart H.A (1894): "Manual of the North Arcot district in the presidency of Madras" by Govt. Central Press-Bombay, Printed at the Government Central Press, Madras

Surhone, L.M. and Timpledon, M.T. and Marseken, S.F. (2010): "Vaddera", published by VDM Publishing, Germany

--Parupally Anjaneyulu  
Senior Research Associate  
Division for Studies in Social Inclusion  
(DSSI)  
Centre for Economic and Social Studies  
Hyderabad (Telangana)

--Sankineni Laxman Rao  
Associate Professor at the DSSI  
Centre for Economic and Social Studies  
Hyderabad (Telangana)



## **IDENTIFYING INTER-LINKAGES BETWEEN FAMILY NETWORKS AND INTER-STATE MARRIAGE MIGRATION IN ROHTAK DISTRICT, HARYANA**

Kavita Singh and Professor Smita Bhutani

### **Abstract**

In Haryana, with an extremely low sex ratio, pressure of continuing the family tree is so enormous that people, who are incapable of finding a suitable bride locally or within the state, create a nexus (network) of contacts in other states and bring brides from different parts of India. Such long distance, inter-state, inter-culture, and inter-caste marriages have been generating a unique type of culturally disparate marriage system in the state of Haryana. Though the phenomenon of such marriages is not new in Haryana (as Jats from Haryana have long been bringing brides from neighboring states like Utter Pradesh, Rajasthan and distant states like Assam, Jharkhand, Bihar, Orissa, Chhattisgarh, Himachal Pradesh, Uttarakhand, West Bengal and Maharashtra) yet the implications of such marriages in the modern-day context are noteworthy. It is in this context that it seems important to examine such marriages which are inter-culture marriages where both the partners are from entirely different socio-cultural backgrounds. This paper examines select inter-linkages, between family networks and inter-state migrant brides and their maternal and paternal status. It has been observed that majority of such brides are poor and they have been brought/bought (mole ke) from distant states including Empowered Action Group (EAG) states of Bihar, Madhya Pradesh, Jharkhand, Orissa, Uttarakhand, Chhattisgarh, Uttar Pradesh, Rajasthan etc. The study is based on primary data collected from the selected villages in Rohtak district by conducting interviews and making observations by visiting individual households selected for this purpose.

### **Introduction**

Migrant networks are sets of interpersonal ties that connect migrants, former migrants, and non-migrants to one another through relations of kinship, friendship, and shared community origin. Network connections increase the likelihood of

international migration because they lower the costs and risks of movement and increase the expected net returns to migration. Having a tie with someone who has migrated yields social capital that people can draw upon to gain access to an important kind of financial capital, that is, high foreign wages, which offer the possibility of accumulating savings abroad and sending remittances home. The effects of social networks remain strong even when controlling for human capital, common household characteristics, and unobserved conditions. However, the inclusion of gender adds complexity due to the varying socio-cultural contexts and the distinct roles and positions of women in developing societies, making it difficult to generalize gender's role in migration processes (Chant and Radcliffe 1992). Taylor (1987) described network ties as a form of "migration capital," with Massey et al. (1987) being the first to specifically identify migrant networks as a source of social capital. Social networks can mitigate stress experienced before, during, and after migration (Cohen and Wills, 1985), supporting the ethnic density hypothesis, which suggests that risk is reduced for migrants living in communities with a higher proportion of people from similar ethnic backgrounds (Veling et al., 2008). Marriage within the same caste and same religion is the thumb rule of the Indian society. While the two institutions have historically been closely linked in Indian culture, their connection is becoming more complex. The relationship between marriage and family is often taken for granted in the popular understanding but with the increasing diversity of family forms in the 21st century such a relationship needs to be reexamined. A kind of culture of migration develops as a result of the expansion of networks. The main characteristic of such a culture is that migration is an accepted and desirable method for achieving social and economic mobility, a higher income, or an improved lifestyle, which cannot be sustained exclusively by dependence on local resources. The social capital theory assigns importance to the functioning of interpersonal social networks between migrants in receiving countries and relatives in sending countries (Hugo 1981; Sycip and Fawcett 1988; Taylor 1986).

### **Study Region**

Haryana covers an area of 44,212 sq. km and is inhabited by 25,351,462 persons as per 2011 census. Density of population in Haryana is 573 persons per sq. km. Rohtak is one of the 22 districts of the state of Haryana which is located in the central part of the state. Rohtak district has four Tehsils i.e., Rohtak, Meham, Kalanaur, Sampla. There are 147 villages and 140 panchayats in the district.

Rohtak lies 70 kilometers north-west of New Delhi and 250 kilometers south of the state capital Chandigarh on NH 9. Rohtak is the sixth most populous city in the state of Haryana with a population of 373,133 as per the 2011 census figures. The population in 2001 was 294,577, and the population growth rate during 2001-2011 was 26.7%. Spread over an area of 72.18 square kilometers (27.87 sq. mi), Rohtak is inhabited by 75,528 families, and the population density of the city is 5,186 persons per square kilometer, which is higher than the state average density of 573 persons per square kilometer. The state had a sex ratio of 879 females per 1,000 males (2011) along with the literacy rate of 84.08 percent. Imbalances of the sex ratio in the state result in the need to bring brides from other states.

### **Objective**

To identifying the webbing of family networks and inter-state marriage migration and analysis the patterns and flows of migrant's brides in Rohtak district.

### **Material and Methodology**

This paper draws upon the larger study of inter-state marriages in Rohtak district Haryana. Based largely on qualitative research, data was collected through interviews, focus groups, note taking, and participant observation, from 15 villages in the district of Rohtak. In the interview schedule both open and close-ended questions were included in order to avoid subjectivity. The observation method was employed to ascertain the reliability and the validity of the information. Given the absence of sufficient numerical data and sampling frame on such marriages, snowball or referral sampling was employed to identify couples with inter-state migrant brides and select the sample of 600 households with such couples from purposely selected 15 villages of Rohtak.

### **Results and Discussion**

#### **Webbing of Family Networks and Marriage Migration**

In order to understand the inter-linkages of family networks with inter-state marriages in the study area, factors influencing the decision-making process for materializing such marriages were identified. Networks are increasingly seen as crucial to understanding patterns of migration, settlement, employment and links with 'home' (Castles and Miller, 2003; Jordan and Duvell, 2003). Women who migrate for marriage, especially to areas where they have no prior caste and kinship links, tend to create marriage networks around themselves. Thus, such marriages

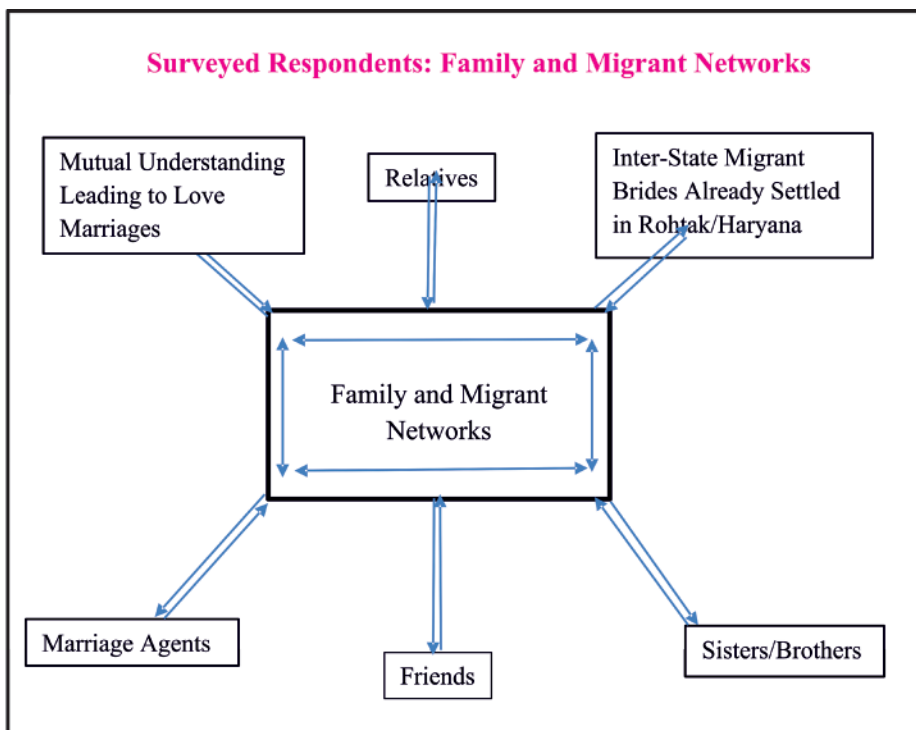


Fig. 1

need to be understood within an approach that combines the economic perspective of marriage migration as household strategies with the one that looks at the social implications and consequences of such marriages (Emma Lundholm 2015). Regional variations in access to local family networks have implications for future care burdens in different regions as well as the living conditions for both older and younger generations. The geographical distance between family members is a long-term consequence of accumulated migration and non-migration undertaken by the individual as well as other family members. The issue of local family networks is not only relevant in relation to elderly care, but is also a potential resource for both older and younger generations (Hjalm 2011; Mulder and van der Meer 2009). Migrant networks are one such element of social context that strongly affect the migration decision through the cost side of the equation. Migration may begin for a variety of reasons, but once the number of migrants reaches a certain level, expanding networks cause the costs of movement to fall and the probability of migration to rise; these trends feed off one another, and over time migration spreads outward to encompass all segments of a society.

This feedback occurs because the networks are created by the act of migration itself (Douglas S. M, 1990). Marriage migration is so pervasive and marriage migration is the primary determinant of sex ratios for adults at the village level since most of the women come from outside it. Since there are substantial differences at the state and district level in gender ratios (Guilmoto and Depledge, 2008), it seems reasonable to suppose that some portion of marriage migration is driven by these imbalances. Areas with low female to male ratios may pull women in as the demand for brides is higher in these areas. These problems are exacerbated with marriage migration since the marriage and migration decisions are typically made by the woman's parents and not the migrant. That means there is still much work to be done to understand marriage migration (Mazumdar, Neetha, and Agnihotri, 2013). The experiences of migrants demonstrate the importance of spatially dispersed networks. As Kelly and Lusia (2006) note, emotional support is sometimes sought not from local networks but through transnational communication (Fig. 1). The largest number of these marriages are arranged by inter-state brides who tap into their natal social, kin, and caste networks back home to locate women who can potentially become inter-state brides. Consequently, certain caste categories are more produced than others in inter-state marriages. Potential grooms also do not insist on caste equals as they often have a fuzzy understanding of natal-region caste groups or ranking in caste hierarchy due to 'alien' sounding jati and gotra names, and the absence of exact caste equivalents to facilitate comparisons.

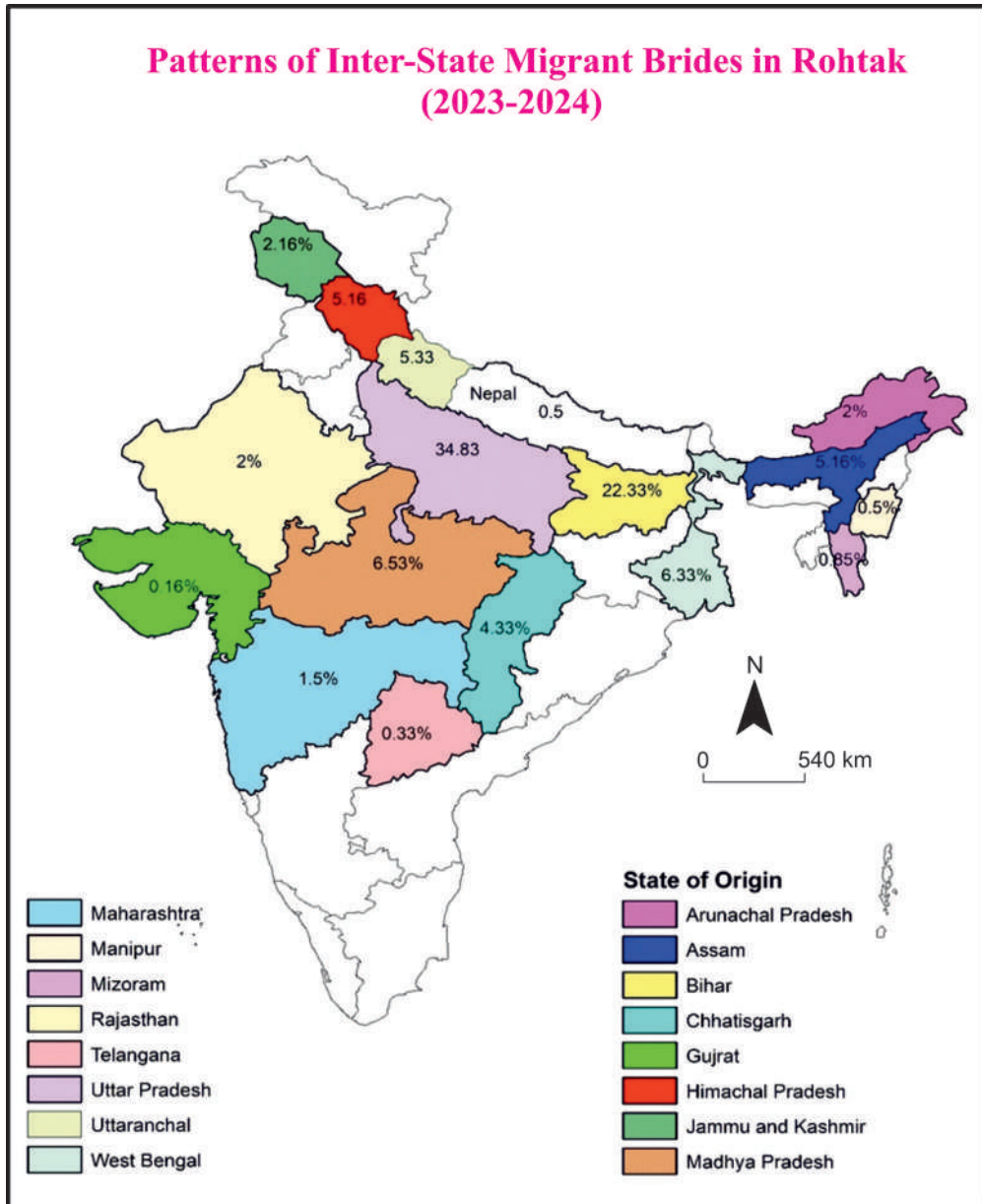


Fig. 2

As mentioned above, 600 households with inter-state migrant brides were selected for the collection of data to identify interlinkages between family networks and inter-state marriage migrant.

### **Patterns and Flows of Migrants Brides**

It was observed that out of the total 600 respondents, Uttar Pradesh has the highest number of respondents, with 209 individuals accounting for 34.83% of the total. Bihar follows, contributing 134 respondents, which is 22.33% of the total. Some states like Madhya Pradesh, West Bengal, Uttarakhand, Himachal Pradesh, and Assam have moderate representation, each ranging between 5% and 7% of the total respondents. Chhattisgarh and Jammu & Kashmir represented 4.33 percent and 2.16 percent of the respondents, respectively. The states of Rajasthan, Arunachal Pradesh, Maharashtra, Mizoram, and Manipur had even lower percentages, with 2 percent, 2 percent, 1.5 percent, 0.83 percent, and 0.5 percent of respondents, respectively. Only 1 respondent (0.16%), was reported to be from Gujarat and 2 respondents (0.33%) were from Telangana. The presence of Nepali respondents in the data is a testament to the enduring and multifaceted relationship between India and Nepal. Marriage migration between these two countries is a unique phenomenon driven by historical ties, legal frameworks, cultural similarities, and economic factors. This aspect of the data enriches our understanding of regional migration patterns and their implications. It is interesting to know that Nepal, is the only country listed apart from Indian states, and included 3 respondents (0.5%) as inter-state migrant brides (Fig. 2). Family networks often play a pivotal role in matchmaking. Relatives, friends, or community members may introduce prospective partners from different states to each other. These introductions can facilitate inter-state marriages by bringing together individuals who might not have otherwise met. The local family network should be seen as a resource for all ages in which the elderly members make a significant contribution. Studies in Sweden and in Europe have shown that the older generation provides more financial and functional support to the younger generation, rather than the other way around (Albertini et al. 2007; Hoff 2007). In the present study it has been found that the brides who had already migrated to Haryana from other states along with their family and relatives also act as mediators in establishment of new marriages relationships. They establish linkages between new families of both the bride and bride-groom sides. For example, an already married inter-state migrant bride may ask her parents and relatives to marry her sister or cousin to the brother or cousin of her husband.

Table-1: State/Country of Origin of Inter-State Migrant Brides

Sl. No.	States/Country of Origin	No. of Respondents	As percent of the total respondents
1.	Gujarat	1	0.16
2.	Telangana	2	0.33
3.	Manipur	3	0.5
4.	Mizoram	5	0.85
5.	Maharashtra	9	1.5
6.	Arunachal Pradesh	12	2
7.	Rajasthan	12	2
8.	Jammu & Kashmir	13	2.16
9.	Chhattisgarh	26	4.33
10.	Assam	31	5.16
11.	Himachal Pradesh	31	5.16
12.	Uttarakhand	32	5.33
13.	West Bengal	38	6.33
14.	Madhya Pradesh	39	6.53
15.	Bihar	134	22.33
16.	Uttar Pradesh	209	34.83
17.	Nepal*	03	0.5
Total		600	100.0

Source: Based on Field Survey (October 2023-April 2024)

\*3 Brides have reported to have come from Nepal

They were encouraged to marry in other states because of prior established linkages. Another important factor affecting the inter-state marriages is the presence of Marriage Agents. Presence of marriage agents also promotes inter-state marriage migration. These agents charge huge amount of money from the groom side and connect the bride's and groom's families. Cultural and social support forms another significant aspect of inter-linkages and family networks in inter-state marriages. This type of support can be essential for helping couples navigate the complexities of merging two different cultural backgrounds and adjusting to life in a new state. It was observed that family networks in the present study provided cultural and

social support to inter-state couples, helping them navigate differences in customs, traditions, and languages. Relatives can offer guidance on how to adapt to a new cultural environment and provide a sense of belongingness. Family networks can sometimes play a role in conflict resolution within the marriage. They may mediate disputes and help the couple find common ground.

Table-2: Percentage Share of Mediators in Inter-State Brides Migration

Type of Mediators	Respondents	Percent of the total respondents
Already Settled in Rohtak/Haryana Inter-State Migrant Brides	168	28.0
Marriage Agents (Bicholiya)	129	21.5
Relatives	287	47.8
Mutual Understanding (Turning into love marriage)	16	2.7
Total	600	100.00

Source: Based on Field Survey (October 2023-April 2024)

However, family involvement can also escalate conflicts if not handled carefully. Inter-state marriages can sometimes lead to the preservation and blending of traditions from both the states to which the partners belong. Family networks can ensure that cultural practices and traditions are upheld within the marriage and passed on to future generations. While family networks can provide support, they can also create pressure and expectations that the couple may struggle to meet. Balancing the desires and expectations of both families can be a challenge in inter-state marriages. Family networks and inter-linkages thus play a multifaceted role in inter-state marriages. They can provide invaluable support, facilitate cultural exchange, and help couples navigate challenges. However, managing family expectations and maintaining a balance between two different family networks can also pose unique challenges for couples in such marriages. Understanding and leveraging the positive aspects of these networks while addressing potential challenges are crucial for the success and happiness of inter-state marriages.

### Conclusion

Inter-state marriages often involve a cultural exchange through family network. It is evident from the analysis of the primary data that inter-linkages between family

networks and inter-state marriage migration play a significant role in the institution of inter-caste, inter-culture marriages in the study area. Inter-state couples rely on family networks to gain parental consent in the first instance. The already married women in Rohtak or in some other parts of Haryana play a significant role in getting their sisters/ neighbors married in Rohtak and these women also help the newly arrived brides to get adjusted and assimilated in the new cultural setup. Family networks provide emotional support during the transition period of such inter-state, inter-culture marriages. They offer advice, encouragement, and a sense of security. In cases of homesickness or adjustment difficulties, family networks turn out to be a crucial source of comfort. This leads to greater cultural awareness and appreciation. Sincere efforts may however be required from both the sides to convince parents and involve extended family members in strengthening such marriages. Such networks can further facilitate gatherings and reunions, allowing the couple to stay connected with their families enriching the lives of both the partners and their families though belonging to different states. Family networks can thus help maintain long-distance inter-state marriage relationships by providing a support system through communication, understanding and visits. Such networks if nurtured properly can provide excellent sharing, blending and celebration of different cultural backgrounds and traditions.

## References

- Albertini, M., Kohli, M., & Vogel, C. (2007). Intergenerational transfers of time and money in European families: common patterns different regimes. *Journal of European social policy*, 17(4), 319-334.
- Castles, S., Miller, M. J., & Ammendola, G. (2005). *The Age of Migration: International Population Movements in the Modern World*: New York: The Guilford Press, (2003), \$30.00, 338 pages.
- Chant, S., & Radcliffe, S. A. (1992). Migration and development: the importance of gender. *Gender and migration in developing countries*, 1-29.
- Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychological bulletin*, 98(2), 310.
- Guilmoto, C. Z., & Depledge, R. (2008). Economic, social and spatial dimensions of India's excess child masculinity. *Population*, 63(1), 91-117.
- Hjalm, A. (2011). *A family landscape: On the geographical distances between elderly parents and adult children in Sweden* (Doctoral dissertation, Umeå University, Department of Social and Economic Geography).
- Hoff, A. (2007). Patterns of intergenerational support in grandparent-grandchild and parent-child relationships in Germany. *Ageing & Society*, 27(5), 643-665.
- Hugo, G. J. (1981). Village-community ties, village norms, and ethnic and social networks: A review of evidence from the Third World. *Migration decision making*, 186-224.
- Kelly, P., & Lusic, T. (2006). Migration and the transnational habitus: evidence from Canada and the Philippines. *Environment and planning A*, 38(5), 831-847.

- Lundholm, E. (2015). Migration and regional differences in access to local family networks among 60-year-olds in Sweden. *Journal of population ageing*, 8, 173-185.
- Massey, D. S. (1990). Social structure, household strategies, and the cumulative causation of migration. *Population index*, 3-26.
- Massey, Douglas S., Rafael Alarcón, Jorge Durand, and Humberto Gonzalez. (1987) *Return to Aztlan: The Social Process of International Migration from Western Mexico*. London, England: University of California Press.
- Mazumdar, I., Neetha, N., & Agnihotri, I. (2013). Migration and gender in India. *Economic and Political Weekly*, 54-64.
- Mulder, C. H., & Van der Meer, M. J. (2009). Geographical distances and support from family members. *Population, space and place*, 15(4), 381-399.
- Singh, Kavita & Bhutani, Prof. (2023). Adjustment and Assimilation of Inter-State Migrant Brides in Haryana: A Case Study of Village Kharanthi.
- Sycip, L. M., & Fawcett, J. T. (1988). Expectations, Family Networks and Emigration: A Study of Filipino Decision-Making. *Philippine Journal of psychology*, 21(1).
- Taylor, J. E. (1987). Undocumented Mexico—US migration and the returns to households in rural Mexico. *American journal of agricultural economics*, 69(3), 626-638.
- Veling, W., Susser, E., Van Os, J., Mackenbach, J. P., Selten, J. P., & Hoek, H. W. (2008). Ethnic density of neighborhoods and incidence of psychotic disorders among immigrants. *American Journal of Psychiatry*, 165(1), 66-73.

--Kavita  
Research Scholar  
Department of Geography  
Panjab University (Chandigarh)

--Prof. Smita Bhutani  
Professor, Department of Geography  
Panjab University (Chandigarh)



## **DECADAL ANALYSIS OF NET SOWN AREA AND GROSS CROPS UNDER FOOD CROPPED IN JAUNPUR DISTRICT, UTTAR PRADESH**

Divya Tiwari and Dr. Abhishek Dubey

### **Abstract**

This study investigates the agricultural efficiency and focus on food crop cultivation across various development blocks in Jaunpur district over three time periods: 2010-11, 2020-21, and 2021-22. The primary objectives are to evaluate changes in agricultural productivity by comparing the percentage of net sown area to total sown area and to assess trends in food crop cultivation by analyzing the percentage of gross sown area dedicated to food crops. Data for this analysis is derived from agricultural records of Jaunpur district, detailing these percentages for the specified years. The net sown area represents the actual cultivated area, whereas the total sown area includes multiple cropping cycles within a year. The gross sown area under food crops indicates the portion of the total sown area used specifically for cultivating food crops. The data is organized into two tables, each listing 22 development blocks and an average for all blocks. For each block, the percentages for the specified years are recorded. To analyze agricultural efficiency, the ratio of net sown area to total sown area is examined to understand the extent of land utilization and cropping intensity. For instance, Suithakala showed an increase from 169.1% in 2010-11 to 186.07% in 2020-21, followed by a slight decrease to 172.63% in 2021-22. Similar patterns are observed in Shahganj, Khutahan, and Karanjakala, indicating fluctuations in agricultural productivity. To assess the focus on food crops, the percentage of gross sown area under food crops is analyzed. For example, Suithakala's percentage decreased from 96.7% in 2010-11 to 89.24% in 2020-21 and then increased to 93.16% in 2021-22. This trend analysis across blocks such as Shahganj, Khutahan, and Karanjakala reveals shifts in agricultural priorities and practices. The study concludes with an overall analysis indicating an increase in the average percentage of net sown area to total sown area from 169.02% in 2010-11 to 181.52% in 2020-21, followed by a decrease to 171.88% in 2021-22. Similarly, the average percentage of gross sown area

under food crops decreased from 93.44% in 2010-11 to 87.76% in 2020-21, then rose to 94.19% in 2021-22.

## **Introduction**

Agriculture forms the backbone of the Jaunpur district's economy, playing a critical role in the livelihoods of its inhabitants. To better understand the dynamics of agricultural productivity and land use, two key metrics are analyzed: the percentage of net sown area to total sown area, and the percentage of gross sown area under food crops. These metrics provide insights into how efficiently the agricultural land is being utilized and the extent to which food crops dominate the agricultural landscape. The analysis focuses on data from 22 development blocks within Jaunpur district, spanning three time periods: 2010-11, 2020-21, and 2021-22. The net sown area is the land actually cultivated with crops, while the total sown area includes land used for multiple cropping cycles within a year. The gross sown area under food crops indicates the total area dedicated specifically to food crop cultivation. Understanding the changes in these percentages over time helps in evaluating the agricultural efficiency and shifts in crop focus. For instance, Suithakala block showed an increase in the percentage of net sown area to total sown area from 169.1% in 2010-11 to 186.07% in 2020-21, with a slight decrease to 172.63% in 2021-22. Such fluctuations are critical for assessing the productivity and sustainability of agricultural practices. Similarly, the focus on food crops is examined through the percentage of gross sown area under food crops. Suithakala's data reveals a decrease from 96.7% in 2010-11 to 89.24% in 2020-21, followed by an increase to 93.16% in 2021-22. These trends, observed across various blocks like Shahganj, Khutahan, and Karanjakala, indicate changing agricultural priorities and practices over the decade. The analysis aims to provide a comprehensive understanding of agricultural efficiency and crop focus, aiding in informed decision-making for future agricultural planning and policy development. By examining these metrics, stakeholders can identify areas of improvement and implement strategies to enhance agricultural productivity and sustainability in the Jaunpur district. This study serves as a valuable resource for policymakers, agriculturalists, and researchers dedicated to advancing the agricultural sector in the region.

## **Study Region**

Jaunpur district, located in the eastern part of Uttar Pradesh, India, is part of the Varanasi division and boasts a rich historical and cultural heritage.

Spanning approximately 4,038 square kilometers, it is bordered by Sultanpur, Azamgarh, Ghazipur, Varanasi, and Pratapgarh districts. The district, characterized by plains and the Gomti River, is divided into six tehsils and 21 development blocks, with numerous villages and towns, including its headquarters, Jaunpur city. According to the 2011 Census, it has a population of around 4.5 million, with Hindi, Urdu, and Bhojpuri being the primary languages. Jaunpur's economy is predominantly agricultural, with major crops like rice, wheat, sugarcane, pulses, and oilseeds, alongside small-scale industries in weaving, pottery, handloom, and perfume production. Historically significant, Jaunpur was founded by Feroz Shah Tughlaq in 1360 A.D. and flourished during the Sharqi Sultanate, with notable monuments such as the Atala Masjid, Jama Masjid, Lal Darwaza Masjid, and Shahi Bridge. Festivals like Diwali, Holi, Eid, and Ganga Dussehra are celebrated with zeal. The district has several educational institutions, including Veer Bahadur Singh Purvanchal University, and healthcare facilities comprising hospitals and clinics. Jaunpur is well-connected by road via National Highway 56, multiple state highways, and Jaunpur Junction railway station, with the nearest airport in Varanasi, approximately 55 kilometers away

### **Objectives**

- (1) To evaluate the changes in net sown area to total sown area in various development blocks of Jaunpur district over the years 2010-11, 2020-21 and 2021-22.
- (2) To examine the trends in food crop cultivation by analysing the percentage of gross sown area in Jaunpur district during the years 2010-11, 2020-21, and 2021-22.

### **Database and Methodology**

The data for this analysis is derived from agricultural records of Jaunpur district, detailing the percentages of net sown area to total sown area and the percentages of gross sown area under food crops for the years 2010-11, 2020-21, and 2021-22. The net sown area represents the actual cultivated area, whereas the total sown area includes multiple cropping cycles within a year. The gross sown area under food crops is the portion of the total sown area used specifically for cultivating food crops. The data is organized into two tables, each listing 22 development blocks and an average for all blocks. For each block, the percentages for the specified years are recorded. To analyze agricultural efficiency, the ratio of net sown area to total sown area is examined to understand the extent of land utilization and cropping intensity.

For instance, Suithakala showed an increase from 169.1% in 2010-11 to 186.07% in 2020-21, followed by a slight decrease to 172.63% in 2021-22. Similar patterns are observed in Shahganj, Khutahan, and Karanjakala, indicating fluctuations in agricultural productivity. To assess the focus on food crops, the percentage of gross sown area under food crops is analyzed. For example, Suithakala's percentage decreased from 96.7% in 2010-11 to 89.24% in 2020-21 and then increased to 93.16% in 2021-22. This trend analysis across blocks such as Shahganj, Khutahan, and Karanjakala reveals shifts in agricultural priorities and practices. The methodology involves comparing the year-wise data for each block to identify trends and deviations, providing insights into agricultural efficiency and crop focus over a decade in Jaunpur district. This comprehensive approach helps in understanding the changes in agricultural land use and crop cultivation patterns, facilitating informed decision-making for future agricultural planning and policy development.

### **Percentage of Net Sown Area to Total Sown Area**

The table, titled "Percentage of Net Sown Area to Total Sown Area of Jaunpur Districts," presents the percentage of net sown area to the total sown area for various development blocks within the Jaunpur district across three time periods: 2010-11, 2020-21, and 2021-22. Each development block's data shows the ratio of net sown area to total sown area, reflecting agricultural productivity and its changes over the years. For example, Suithakala's percentages were 169.1% in 2010-11, increased to 186.07% in 2020-21, and slightly decreased to 172.63% in 2021-22. Similar trends are observed across other blocks like Shahganj, Khutahan, and Karanjakala, among others, with some blocks showing consistent increases and others fluctuating. The table concludes with the average for all development blocks, indicating an overall trend where the percentages increased from 169.02% in 2010-11 to 181.52% in 2020-21, then decreased to 171.88% in 2021-22. This comprehensive data provides insights into the agricultural efficiency and productivity changes over the decade in the Jaunpur district.

### **Percentage of Gross Sown Area under Food Crops**

The table, titled "Percentage of Gross Sown Area under Food Crops," presents data on the percentage of gross sown area allocated to food crops for various development blocks within the Jaunpur district across three time periods: 2010-11, 2020-21, and 2021-22. Each development block's data shows the proportion of the total sown area used for growing food crops, indicating the focus on food crop cultivation over the years.

Table-1: Net Sown Area to Total Sown Area in Jaunpur District

Blocks	2010-11	2020-21	2021-22
Suithakala	169.1	186.07	172.63
Shahganj	168	184.4	174.53
Khutahan	171.6	188.7	178.36
Karanjakala	165.8	181.33	173.7
Badlapur	168.3	175.04	167.52
Maharajganj	169.1	184.97	175.49
Baksa	168.2	184.78	176.62
Sujanaganj	168.7	185.25	176.96
Mugarabadshahpur	168.4	170.66	163.47
Machhlishahar	168.1	172.28	165.85
Madiyahu	169.1	184.24	175.8
Barsathi	168.1	168.85	161.53
Sikarara	169.6	178.42	169.58
Dharmapur	173.8	180.96	168.83
Ramnagar	167.8	178.75	168.68
Rampur	168.8	175.27	166.42
Muftiganj	170.1	179.85	167.42
Jalalpur	169.6	178.9	167.75
Kerakat	169.1	186.24	176.75
Dobhi	168.6	186.82	175.43
Sirkoni	169.5	200.16	186.11
All Development Blocks	169.02	181.52	171.88

Source: Authors

For instance, Suithakala had a percentage of 96.7% in 2010-11, which decreased to 89.24% in 2020-21 and then increased to 93.16% in 2021-22. Similar trends are observed across other blocks like Shahganj, Khutahan, and Karanjakala, with some showing steady increases and others fluctuating. The table concludes with an average for all development blocks, where the percentage was 93.44% in 2010-11, dropped to 87.76% in 2020-21, and then rose to 94.19% in 2021-22.

This data provides insights into the agricultural focus on food crops and how it has changed over a decade in the Jaunpur district.

Table-2: Gross Sown Area under Food Crops of Jaunpur Districts

Development Block	2010-11	2020-21	2021-22
Suithakala	96.7	89.24	93.16
Shahganj	97	88.51	90.68
Khutahan	93.1	85.74	91.95
Karanjakala	97.9	84.32	91.46
Badlapur	83.3	80.7	85.85
Maharajganj	85.4	79.16	85.06
Baksa	87.1	80.73	87.78
Sujanaganj	96.6	93.41	98.36
Mugarabadshahpur	93.3	95.76	100.92
Machhlishahar	94.9	94.65	99.18
Madiyahu	98.7	92.6	97.86
Barsathi	92.9	94.68	100.92
Sikarara	94.9	87.91	97.01
Dharmapur	99.1	80.23	92.45
Ramnagar	99.9	93.46	99.37
Rampur	85	82.79	88.85
Muftiganj	98.9	94.99	103.34
Jalalpur	95.8	92.29	99.87
Kerakat	96	88.29	95.74
Dobhi	92.4	84.36	91.37
Sirkoni	83.4	79.14	86.7
All Development Blocks	93.44	87.76	94.19

Source: Authors

## Conclusion

The analysis of agricultural efficiency and focus on food crops in Jaunpur district over the years 2010-11, 2020-21, and 2021-22 reveals significant trends and shifts in land use and crop cultivation patterns. The percentage of net sown

area to total sown area indicates fluctuating agricultural productivity, with blocks like Suithakala, Shahganj, and Khutahan showing varying degrees of increase and decrease over the decade. Similarly, the percentage of gross sown area under food crops highlights changes in agricultural priorities, with some blocks experiencing a decline followed by a resurgence in food crop cultivation. Overall, the average data for all development blocks shows a general increase in agricultural efficiency from 169.02% in 2010-11 to 181.52% in 2020-21, before a slight decline to 171.88% in 2021-22. The focus on food crops, however, saw a decrease from 93.44% in 2010-11 to 87.76% in 2020-21, with a recovery to 94.19% in 2021-22. These trends reflect the dynamic nature of agricultural practices in Jaunpur district, influenced by various factors such as policy changes, climatic conditions, and market demands. This comprehensive analysis provides valuable insights for policymakers, agriculturalists, and researchers, aiding in the development of informed strategies to enhance agricultural productivity and sustainability. The findings underscore the importance of continuous monitoring and adaptation to ensure the effective use of agricultural land and the promotion of food security in the region.

## **References**

- Government of India, Ministry of Agriculture and Farmers Welfare. (2020). *Agricultural Statistics at a Glance 2020*.
- Sharma, V. P. (2016). Dynamics of Agricultural Development and Rural Economy in India. *Indian Journal of Agricultural Economics*, 71(1), 1-34.
- Indian Council of Agricultural Research. (2019). *Annual Report 2018-19*.
- Singh, S., & Chand, R. (2011). Fertilizer Use, Nutrient Imbalance and Subsidies: Trends and Implications. *Economic and Political Weekly*, 46(12), 68-77.
- Planning Commission of India. (2011). *Report of the Working Group on Agriculture for the Twelfth Five Year Plan (2012-17)*.
- Kumar, P., Kumar, A., & Parappurathu, S. (2019). Public Investment in Agricultural Research and Extension in India: Trends and Patterns. *Agricultural Economics Research Review*, 32(1), 27-40.
- Department of Agriculture, Cooperation & Farmers Welfare. (2021). *Agricultural Statistics*.
- Swaminathan, M. S. (2012). From Green to Evergreen Revolution: Indian Agriculture Performance and Challenges.
- National Sample Survey Office (NSSO). (2013). *Key Indicators of Land and Livestock Holdings in India*.
- Fertiliser Association of India. (2020). *Fertiliser Statistics 2019-20*.
- World Bank. (2014). *Republic of India: Accelerating Agricultural Productivity Growth*.
- Gulati, A., & Banerjee, P. (2015). Emerging Trends in Indian Agriculture: What Can We Learn from Other Countries? *Indian Journal of Agricultural Economics*, 70(1), 1-25.
- Food and Agriculture Organization (FAO). (2019). *State of Food and Agriculture*.

- Saxena, R. (2017). Impact of Climate Change on Indian Agriculture. *International Journal of Environmental Sciences*, 6(5), 723-732.
- Chand, R., & Pal, S. (2014). Agriculture in India: Performance, Challenges and Opportunities. *Indian Journal of Agricultural Economics*, 69(1), 1-17.
- National Bank for Agriculture and Rural Development (NABARD). (2018). NABARD Annual Report 2017-18.
- Census of India. (2011). Primary Census Abstract.
- Kumar, P., & Sharma, A. (2013). Crop Diversification in Eastern India: Status and Determinants. *Indian Journal of Agricultural Economics*, 68(2), 176-194.
- Yadav, S. K., & Singh, R. (2017). An Analysis of Productivity and Efficiency of Indian Agriculture. *Journal of Agricultural Sciences*, 9(4), 121-130.
- Government of Uttar Pradesh. (2021). Statistical Abstract Uttar Pradesh 2020-21.

--Divya Tiwari  
PhD Scholar  
Department of Economics  
University of Allahabad  
Prayagraj (Uttar Pradesh)

--Dr. Abhishek Dubey  
Assistant Professor  
Department of Geography  
Fundi Singh Launa Government  
Degree College, Jalaun



## **SPATIO-TEMPORAL STUDY ON POPULATION DYNAMICS AND FORECASTING IN EAST SIANG DISTRICT OF ARUNACHAL PRADESH, INDIA**

Diram Bori, Trisha Deka, Satyabrat Sonowal and Dr. Shukla Acharjee

### **Abstract**

This paper presents a comprehensive study on the population dynamics in East Siang District of Arunachal Pradesh. The primary objective of this study is to understand the spatial and temporal patterns of change in population over the last three decades (1991-2021) and forecasting the population in the district. Geometric Progression Method of population forecasting has been utilized to find out the projected population. The findings of the study reveal a trend of increasing urban population in the district.

### **Introduction**

Population dynamics, a key component of human geography, has long been a critical subject of study for understanding demographic changes, migration patterns, and their socio-economic impacts. The scope of population geography is very wide as there are many aspects attributes of population (Ranade, P. S. (1990). This paper focuses on the East Siang district of Arunachal Pradesh, a region characterized by its unique geographical features and cultural diversity. The district, part of the northeastern frontier of India, presents a distinct case for examining population trends due to its varied topography, socio-economic conditions, and developmental challenges. Arunachal Pradesh, located in the eastern Himalayas, is known for its diverse ethnic communities and complex demographic patterns. The state has witnessed significant demographic changes over the past few decades, driven by factors such as migration, fertility rates, and policy interventions (Census of India, 2011). East Siang, one of its key districts, provides a microcosmic view of these broader trends. The district's population dynamics are influenced by its agrarian economy, border proximity, and infrastructural development, which collectively shape its demographic profile. The study of population dynamics in East Siang is

crucial for several reasons. Firstly, understanding population trends aids in effective regional planning and resource allocation. Secondly, spatio-temporal analysis helps in identifying patterns of population distribution and growth, which are essential for infrastructure development, health care provisioning, and educational planning. This research employs a spatio-temporal approach to analyze population data over a specific period, providing a comprehensive view of demographic changes. By integrating Geographic Information System (GIS) tools with statistical methods, this study aims to map population distributions, analyze trends, and forecast future population scenarios in East Siang.

### **Study Region**

The geographical location of East Siang district is in between 27°43' and 29°20' North latitude and 94°42' and 95°35' East latitude (**Fig. 1**). The district spreads over a wide range of altitudinal height of mean sea level from a minimum of 133 ft. (Ruksin area) and maximum 752 ft. (Riga) (Das M., Jaishi A., Sarma H. N., 2013). The “Siyom” and “Siku” are two main tributaries of Siang River, flowing across the west and east bank of the mighty Siang respectively. (Das M., Jaishi A., Sarma H. N., 2013). East Siang is one of the oldest districts of Arunachal Pradesh (AP), its headquarter is at Pasighat town which is the first connecting link between the AP state and mainland India (Joanica et al. 2020). Recently, the District had experienced changes in the boundary, and its size got reduced to 1800 Km<sup>2</sup> from 4005 Km<sup>2</sup> and divided into seven circles viz., Bilat, Mebo, Namsing, Pasighat, Sille-Oyan, Ruksin and Yagrung (Joanica et al. 2020). The district's total human population is around 81,882, with 75% (62,001) being tribal, with the majority belonging to the Adi tribe, followed by the Mishing and Galo tribes, and a few residents from the bordering state of Assam (Census of India, 2011). The local population is predominantly engaged in agricultural activity with limited landholdings, relying on primary and secondary forest resources for household needs. The vegetation of the study region is primarily semi-evergreen forest and montane wet temperate forest (Champion, H.G., Seth S.K., 1968).

### **Objectives**

The objectives of this study are threefold: to examine the historical population trends in East Siang district, to analyze the spatial distribution of the population, and to forecast future population changes.

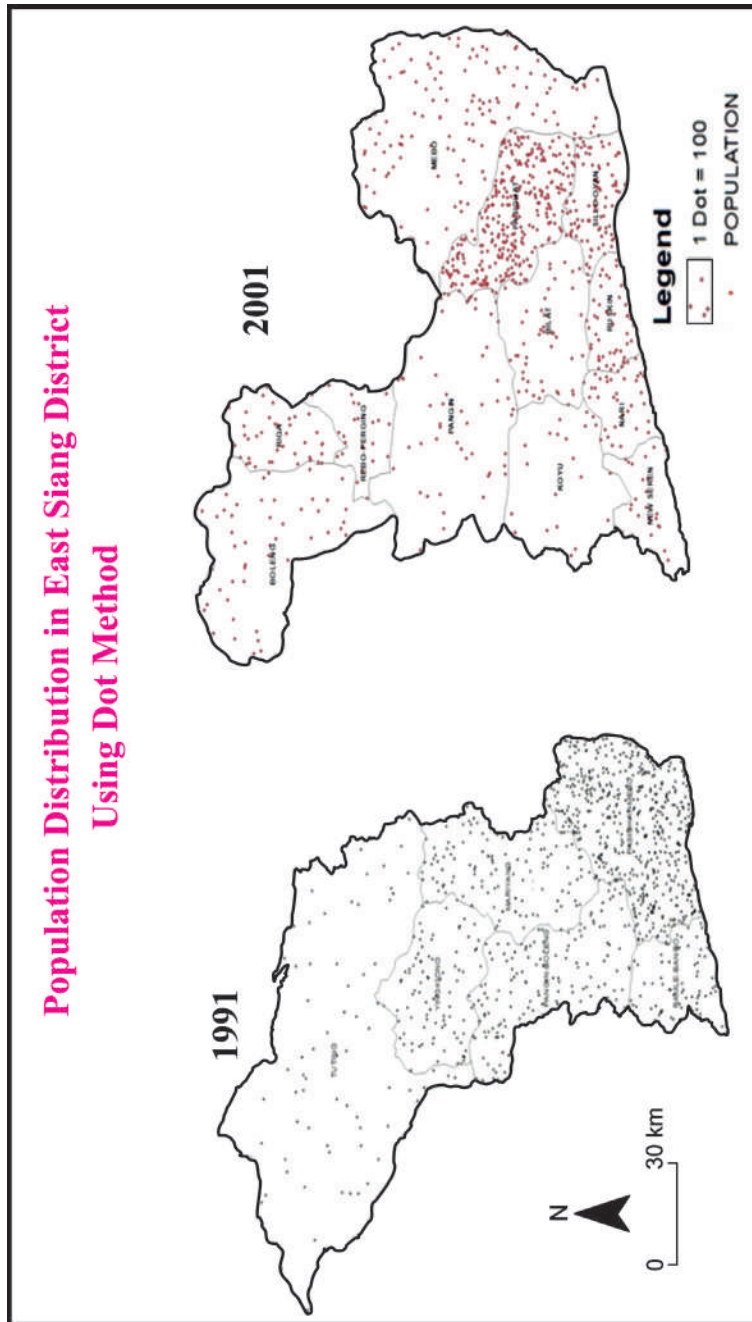


Fig. 1

## Database and Methodology

For the study of population dynamics, population data of the study area have been collected from the district hand books and the Census of India of the year 1991, 2001 and 2011. The collected population data have been organized and Circle wise population distribution maps (1991, 2001 and 2011) has been prepared in ARC GIS 10.3 platform using dot method. Population of the year 2021 has been forecasted with the help of Geometric Population Projection method.

## Results and Discussion

### Rural Urban Population

A district or an urban area experiencing moderate natural increase coupled with huge migration normally shows rapid growth of population (Guchhait, S. K., & Dasgupta, A. 2012). There is a clear trend of population movement from rural to urban areas over the 20-year period (**Table-1**). The percentage of the rural population decreased from 85.309% in 1991 to 72.146% in 2011, while the urban population percentage increased from 14.691% to 27.854% in the same period. This indicates significant urbanization. The decrease in the total population from 1991 to 2001, followed by an increase from 2001 to 2011, suggests fluctuating demographic dynamics. The main influencing factor in this regard is the bifurcation of the district between 1991 and 2001 and other possible reasons for this could be migration, changes in birth and death rates, or other socio-economic factors. The rural population saw a notable decline from 1991 to 2001, followed by a modest increase by 2011 (**Table-1**). This could indicate initial rural-to-urban migration followed by some level of rural area development or return migration. The steady increase in urban population over the years reflects urban growth and possibly better economic opportunities in urban areas, attracting people from rural regions (Fig. 1).

Table-1: Percentage of Rural and Uurban Population in East Siang District

Years	Rural Population	% of Rural Population	Urban Population	% of Urban Population	Total Population
1991	85004	85.309	14639	14.691	99643
2001	65432	74.868	21965	25.132	87397
2011	71579	72.146	27635	27.854	99214

Source: Authors

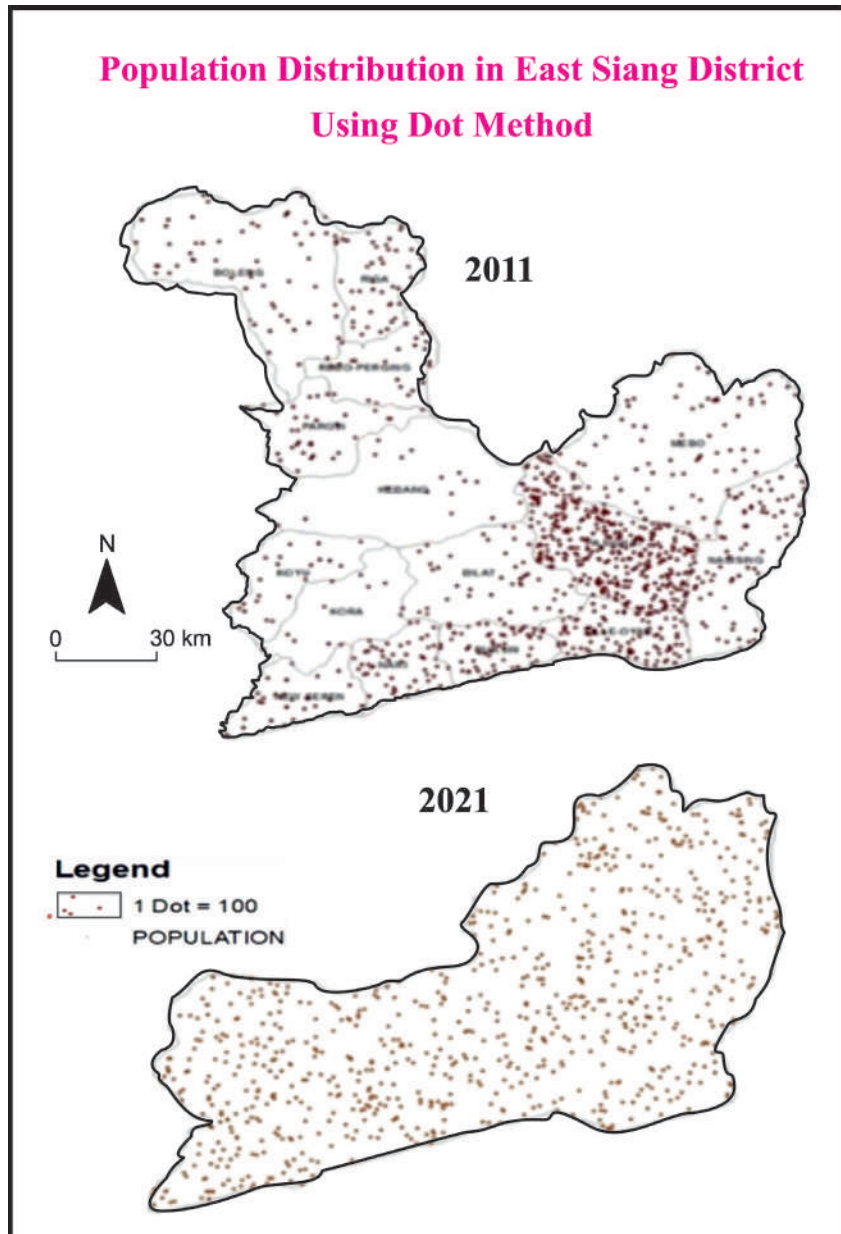


Fig. 2

Table-2: C.D Block/Circle-wise Distribution of Population (1991)

C.D Block/Circle	Rural Population	Urban Population	Total Population
Pasighat-Mebo (C.D Block)	36244	14639	50883
Pasighat	8419	14639	23058
Mebo	10657	0	10657
Ruksin	10589	0	10589
Bilat	4908	0	4908
Koyu	1671	0	1671
Pangin-Boleng (C.D Block)	14297	0	14297
Boleng	7929	0	7929
Pangin	6368	0	6368
Ramle-Bango (C.D Block)	6384	0	6684
Nari	6684	0	6684
Mariyang (C.D Block)	11614	0	11614
Mariyang	6561	0	6561
Geku	5053	0	5053
Yingkiong (C.D Block)	9001	0	9001
Jengging	3526	0	3526
Yingkiong	5475	0	5475
Tuting (C.D Block)	7164	0	7164
Tuting	4484	0	4484
Gelling	960	0	960
Singa	1042	0	1042
Palling	678	0	678
District	85004	14639	99643

Source: District Census Handbook. Part XII-A&B Series-3, Census of India 1991

**Table-2 and 3** highlights significant disparities in population distribution within the district, emphasizing the need for tailored developmental strategies to address the unique needs of both densely and sparsely populated areas. The concentration of both rural and urban populations in Pasighat and Pasighat-Mebo C.D Block (**Fig. 2**) suggests this area is a central hub within the district,

likely offering more services, employment opportunities, and amenities. The presence of a significant urban population exclusively in Pasighat indicates that urbanization is localized, with the rest of the district remaining predominantly rural. The areas with higher populations, especially Pasighat-Mebo, might require more resources, infrastructure, and development initiatives to meet the needs of their larger populations. For balanced development, attention might be needed for areas like Palling and other less populated regions to ensure they are not left behind in terms of basic services and infrastructure.

### Population Forecasting

The COVID-19 outbreak forced the postponement of India's 2021 census. This is the first postponement in India's decennial census since 1881. Here, for the present study of population for 2021 of East Siang district, Geometric Progression Method of population forecasting has been utilized to find out the projected population. The area of present-day East Siang district has been decreased to 2386.34 sq.km in the year 2015 from 3603.00 sq.km of the year 2011. Consequently, the study for projected population of the year 2021 has been analyzed within the reduced administrative boundary of the district including the reduced population for the year 1991, 2001 and 2011 i.e., 57567, 71356 and 73539 respectively. This method is imperative to analyze and find out the accurate deviations in population.

$$\text{Formula} - P_n = P_o \left( 1 + \frac{k}{100} \right)^n$$

Here,  $P_n$  = forecasted population after ‘n’ decades from present known population

$P_o$  = population of present known population

n = number of decades

k = percentage of growth rate

$$k = \sqrt[m]{k_1 \times k_2 \times k_3 \times \dots \times k_m} \text{ (m is constant)}$$

Table-3: Calculation of Forecasted Population 2021 of East Siang District

Sl. No.	East Siang	Population	Increase in Population	Percentage Increase in Population (%)
1	1991	57567	-	-
2	2001	71356	13789	23.95
3	2011	73539	2183	3.05

$$\begin{aligned}
 \text{Here, } k &= \sqrt{k_1 \times k_2} \\
 &= \sqrt{23.95 \times 3.05} \\
 &= \sqrt{73.0475} \\
 &= 8.55
 \end{aligned}$$

Therefore, the value of k is 8.55

$$\begin{aligned}
 \text{Now, } P_n &= P_0 \left(1 + \frac{k}{100}\right)^n \\
 2021 &= 73539 \left(1 + \frac{8.55}{100}\right)^1 \\
 &= 73539 (1 + 0.0855)^1 \\
 &= 73539 (1.0855) \\
 &= 79826.6
 \end{aligned}$$

Therefore, the forecasted population of East Siang district for the year 2021 would be 79827.

## Conclusion

The overall population decreased from 1991 to 2001, due to bifurcation of the district. The increase from 2001 to 2011 suggests recovery and growth, potentially from improved living conditions and economic stability. The results highlight the demographic shifts towards urbanization, with decreasing rural populations and growing urban centres. The notable concentration of the urban population solely in Pasighat suggests that urbanization is confined to this area, while the rest of the district remains largely rural. These trends are crucial for planning and policy-making, particularly in areas such as urban infrastructure development, rural support programs, and overall regional planning to accommodate these changes.

## References

- Census of India. (2011). Primary Census Abstract Data. Government of India.
- Champion, H.G., Seth S.K., (1968). A Revised Survey of the Forest Types of India. Govt. of India Press (1968)
- Das M, Jaishi A, Sarma H N (2013), Traditional medicines of herbal origin practice by the adi tribe of East Siang District of Arunachal Pradesh, India, Global J Res. Med. Plants & Indigen. Med., Volume 2(5): 298–310.

Guchhait, S. K., & Dasgupta, A. (2012). Spatio-Temporal Dynamics of Population Growth of Howrah District in India: An Experience in the 20th Century. *IOSR Journal of Humanities and Social Science (JHSS)*. ISSN: 2279-0837, ISBN: 2279-0845. Volume 3, Issue 4.

Joanica Delicia Jyrwa, Bheem Dutt Joshi, Avijit Ghosh, Yomto Mayi, Mihin Nipa, Ngilyang Anga, Mary Pali, Mukesh Thakur, Kailash Chandra, Lalit Kumar Sharma (2020). Dimensions of changing perception towards wildlife conservation in East Siang district of Arunachal Pradesh, Eastern Himalayas, *Global Ecology and Conservation*, Volume 24, 2020, e01265, ISSN 2351-9894, <https://doi.org/10.1016/j.gecco.2020.e01265>

Ranade, P. S. (1990). *Population dynamics in India*. APH Publishing.

--Diram Bori  
Assistant Professor  
Centre for Studies in Geography  
Dibrugarh University  
Dibrugarh (Assam)

--Trisha Deka  
Student  
Centre for Studies in Geography  
Dibrugarh University  
Dibrugarh (Assam)

--Satyabrat Sonowal  
Student  
Centre for Studies in Geography  
Dibrugarh University  
Dibrugarh (Assam)

--Dr. Shukla Acharjee  
Assistant Professor  
Centre for Studies in Geography  
Dibrugarh University  
Dibrugarh (Assam)



## **QUANTIFICATION OF PROBABILITY OF RECURRENCE OF METEOROLOGICAL DROUGHT IN MYSURU CITY, KARNATAKA**

Dr. Prasanna Kumar K R

### **Abstract**

This study examines the annual rainfall patterns in Mysuru City from 1901 to 2023, utilizing basic descriptive statistics to analyze central tendency, dispersion, and variability within the dataset. The analysis reveals an annual average rainfall of 736.10 mm, with a minimum of 367.55 mm in 2016 and a maximum of 1548.95 mm in 2023. The long-term standard deviation from the mean is 187.44 mm, indicating significant variability in annual precipitation. Additionally, the Standard Precipitation Index (SPI) was calculated to categorize years into dry and humid conditions based on a 12-month scale. The SPI analysis identified several extreme weather years, with dry years categorized as extremely, severely, or moderately dry, and humid years categorized as extremely, severely, or moderately wet. The probability of recurrence of various drought severities was also assessed, revealing that "Near Normal" conditions were the most frequent, occurring 89 times in 123 years, while extreme wet and dry conditions were less frequent. The findings underscore Mysuru City's susceptibility to climate variability, with implications for future climate resilience and risk management. Future research should focus on refining SPI trend analysis and integrating additional climatic indicators to enhance comprehensive climate risk assessments and support sustainable development initiatives.

### **Introduction**

Mysuru City, located in the southern part of India, experiences a monsoon-dominated climate, characterized by significant annual variability in precipitation. Understanding rainfall patterns and their variability is crucial for effective water resource management, agricultural planning, and urban development in the region. The analysis of historical rainfall data provides valuable insights into long-term trends and anomalies, aiding in the development of adaptive strategies to mitigate the impacts of climate variability. This study focuses on two key aspects of precipitation

analysis in Mysuru City: the basic descriptive statistics of annual rainfall from 1901 to 2023 and the application of the Standard Precipitation Index (SPI) to classify years based on moisture conditions. By examining these components, we aim to provide a comprehensive overview of historical precipitation trends and identify periods of drought and excess rainfall. Additionally, the study includes an assessment of the probability of recurrence of various drought severities, offering a historical perspective on drought frequency. The SPI is a widely used tool in climate studies for quantifying precipitation deficits and excesses over multiple time scales. Developed by McKee et al. (1993), the SPI allows for a standardized comparison of precipitation anomalies across different climatic regions (McKee, Doesken, & Kleist, 1993). Its application in this study provides a structured overview of precipitation conditions in Mysuru City, facilitating a deeper understanding of the region's climate dynamics. The scholarly articles collectively focus on drought monitoring, analysis, and prediction using various indices and methodologies. Tirivarombo et al. (2018) and Lotfirad et al. (2022) emphasize the use of the Standardized Precipitation Evapotranspiration Index (SPEI) and the Standardized Precipitation Index (SPI) for drought analysis in different climatic regions, including Iran and Africa.

Mehr et al. (2020) explore the impacts of climate change on meteorological drought in Ankara, Turkey using SPI and SPEI. Choudhury et al. (2021) investigate regional variations of drought parameters across India, while Mallya et al. (2016) and Das et al. (2016) analyze trends and variability of droughts over the Indian monsoon region and the Indian subcontinent, respectively. Pai et al. (2017) discuss the variability of meteorological droughts over India. Bisht et al. (2019) and Shrivastava et al. (2018) focus on drought characterization and prediction under projected climate scenarios and ensemble predictions. Jena et al. (2020) examine extreme droughts in the Cauvery River basin and their correlation with sea surface temperatures. Poornima and Pushpalatha (2019) utilize LSTM recurrent neural networks for drought prediction based on SPI and SPEI, while Joshi et al. (2016) employ wavelet transform to analyze trends and periodicities in drought variables in India. Udmale et al. (2020) propose a statistical approach to defining national-scale meteorological droughts using crop data, and Rehana and Naidu (2021) develop a hydro-meteorological drought index for a semi-arid river basin in Peninsular India, considering climate change impacts. Collectively, these studies highlight the significance of advanced indices, modeling techniques, and climate change considerations in understanding and predicting drought phenomena across diverse geographical settings.

## **Study Region**

Mysuru, also known as Mysore, is a tier-2 city in the southern part of the Indian state of Karnataka. It is situated, about 145 kilometers southwest of Bangalore, the state capital. The city covers an approximate area of 128 square kilometers and lies at an average elevation of 763 meters above sea level. Mysuru has a semi-arid climate with distinct wet and dry seasons. The summer months (March to June) are warm, with temperatures ranging between 20°C and 35°C. The monsoon season (July to September) brings moderate to heavy rainfall, primarily from the southwest monsoon. Winters (October to February) are mild and pleasant, with temperatures between 15°C and 30°C. Geologically Mysuru is characterized by a variety of rock formations, including granite, migmatite, and gneiss. The region has a stable geological foundation, making it less prone to seismic activities. The soil in and around Mysuru is generally red lateritic, which is suitable for certain types of agriculture. Mysuru is a prominent tourist destination, known for its rich cultural heritage and historical landmarks. Mysuru is renowned for its vibrant festivals, especially the Mysore Dasara, which attracts tourists from all over the world.

## **Objectives**

- (1) To study the trends in rainfall of Mysuru City using IMD data
- (2) To assess the drought condition and probability of recurrence of drought in Mysuru city.

## **Materials and Methodology**

The primary dataset for this study comprises annual rainfall records for Mysuru City spanning from 1901 to 2023. These records were sourced from the India Meteorological Department (IMD) Pai et al. (2014) and supplemented by historical climate data archives. The comprehensive dataset ensures robust statistical analysis and accurate representation of long-term precipitation trends. Basic descriptive statistics, including measures of central tendency (mean, median), dispersion (standard deviation, variance), and variability (range, interquartile range), were computed to summarize the annual rainfall data. These statistics provide a foundational understanding of the distribution and variability of precipitation over the 123-year period. The SPI was calculated for a 12-month time scale (annual basis) to categorize each year from 1901 to 2023 into different moisture conditions. The SPI calculation involves fitting a gamma probability distribution

to the historical precipitation data and transforming it into a standardized normal distribution (Edwards & McKee, 1997). The SPI values (**Table-1**) were then used to classify years into categories such as extremely dry, severely dry, moderately dry, near normal, moderately wet, severely wet, and extremely wet (Guttman, 1999).

Table-1: SPI Classification

Sl. No.	Condition	SPI Index
1	Extremely Dry	$SPI \leq -2.0$
2	Severely Dry	$-2.0 < SPI \leq -1.5$
3	Moderately Dry	$-1.5 < SPI \leq -1.0$
4	Near Normal	$-1.0 < SPI < 1.0$
5	Moderately Wet	$1.0 \leq SPI < 1.5$
6	Severely Wet	$1.5 \leq SPI < 2.0$
7	Extremely Wet	$SPI \geq 2.0$

Source: Author

The classification provides a detailed overview of historical precipitation anomalies and identifies specific years of extreme weather conditions. The statistical methods and SPI calculations were performed using standard software tools such as R and Python, ensuring accuracy and reproducibility of results.

## Results and Discussion

### Annual Rainfall in Mysuru City (1901-2023)

Basic descriptive statistics provide a comprehensive summary of the dataset's central tendency, dispersion, and variability, giving insights into the distribution of annual rainfall over the years. Whereas Mysuru City annual average mean between the years (1901-2023) is 736.10mm. Least recorded rainfall is 367.55mm in the year 2016 and maximum rainfall of 1548.95mm in the year 2023. Long term standard deviation from the mean is 187.44 (**Fig. 1**).

### Standard Precipitation Index (SPI)

SPI is typically calculated using historical precipitation data for a specific location. It involves fitting a probability distribution to the precipitation data for a chosen time scale (e.g., 1 month, 3 months, 6 months, and 12 months).

Graph 3 represents SPI of 12 months (Annual basis) from the year 1901- 2023. **Table-2** categorizes years based on their Standardized Precipitation Index (SPI) values into dry and humid conditions. Dry years are classified into three categories: extremely dry, severely dry (1923, 1976, 1990, 2002, and 2016), and moderately dry (1918, 1950, 1955, 1965, 1967, 2003, 2006, 2007, 2019, and 2021). On the other hand, humid years are categorized as extremely wet (1903, 1999, 2017, 2022), severely wet (1916, 1944, 1958, 1977, 1993 and 2005), and moderately wet (1911, 1940, 1954, 1964, 1991, 1997, 2000, 2010 and 2015) (**Fig. 2**). These classifications provide a structured overview of historical precipitation conditions based on SPI analysis.

Table-2: Dry and Humid Years based on SPI values

Sl.No.	Dry Condition	Years
1	Extremely Dry	-
2	Severely Dry	1923, 1976, 1990, 2002, 2016
3	Moderately Dry	1918, 1950, 1955, 1965, 1967, 2003, 2006, 2007, 2019, 2021
	Humid Condition	Years
4	Extremely Wet	1903, 1999, 2017, 2022
5	Severely Wet	1916, 1944, 1958, 1977, 1993, 2005
6	Moderately Wet	1911, 1940, 1954, 1964, 1991, 1997, 2000, 2010, 2015

Source: Author

### Probability of Recurrence of Drought

**Table-3** illustrates the probability of recurrence for various drought severities over a span of 123 years. "Near Normal" conditions occurred most frequently, with 89 instances, translating to an expected frequency of 70 times in 100 years. "Moderately Dry" conditions were observed 10 times, indicating a recurrence rate of 8 times in 100 years. "Moderately Wet" conditions occurred 9 times, which is equivalent to happening 7 times in 100 years. "Severely Wet" conditions were noted 6 times, corresponding to 5 times in 100 years. "Severely Dry" conditions were recorded 5 times, equating to 4 times in 100 years. The least frequent condition was "Extremely Wet," occurring 4 times, or 3 times in 100 years (**Table-3**). These figures provide a historical perspective on the frequency of different drought severities.

Table-3: Probability of recurrence

Sl.No.	Drought Severity	Number of times in 123 years	Severity of event
1	Near Normal	89	70 times in a 100 years
2	Extremely Wet	4	3 times in a 100 years
3	Moderately Wet	9	7 times in a 100 years
4	Severely Wet	6	5 times in a 100 years
5	Moderately Dry	10	8 times in a 100 years
6	Severely Dry	5	4 times in a 100 years

Source: Author

## Conclusion

The analysis of the Standard Precipitation Index (SPI) for Mysore city reveals critical insights into the frequency and severity of droughts over the past 123 years. The data indicates that "Near Normal" conditions are the most common, occurring 89 times, suggesting that Mysore generally experiences moderate and stable precipitation levels. However, the occurrence of extreme conditions—both wet and dry—highlights the city's vulnerability to significant climate variability. By addressing drought parameters, Mysore can enhance its resilience to climate variability and ensure sustainable development in the face of changing precipitation patterns. Future studies should continue to refine the understanding of SPI trends and integrate them with other climatic indicators for a comprehensive climate risk assessment.

## References

- Bisht, D. S., Sridhar, V., Mishra, A., Chatterjee, C., & Raghuvanshi, N. S. (2019). Drought characterization over India under projected climate scenario.
- Choudhury, A., Dutta, D., Bera, D., & Kundu, A. (2021). Regional variation of drought parameters and long-term trends over India using standardized precipitation evapotranspiration index. *Journal of Environmental Management*, 296, 113056.
- Danandeh Mehr, Ali, et al. "Climate change impacts on meteorological drought using SPI and SPEI: case study of Ankara, Turkey." *Hydrological Sciences Journal* 65.2 (2020): 254-268.
- Das, P. K., Dutta, D., Sharma, J. R., & Dadhwal, V. K. (2016). Trends and behaviour of meteorological drought (1901–2008) over Indian region using standardized precipitation–evapotranspiration index. *International Journal of Climatology*, 36(2), 909-916.
- Edwards, D. C., & McKee, T. B. (1997). Characteristics of 20th-century drought in the United States at multiple time scales. *Climatology Report*, 97-2.

- Guttman, N. B. (1999). Accepting the standardized precipitation index: A calculation algorithm. *Journal of the American Water Resources Association*, 35(2), 311-322.
- Jena, P., Kasiviswanathan, K. S., & Azad, S. (2020). Spatiotemporal characteristics of extreme droughts and their association with sea surface temperature over the Cauvery River basin, India. *Natural Hazards*, 104, 2239-2259.
- Joshi, N., Gupta, D., Suryavanshi, S., Adamowski, J., & Madramootoo, C. A. (2016). Analysis of trends and dominant periodicities in drought variables in India: a wavelet transform based approach. *Atmospheric Research*, 182, 200-220.
- Lotfirad, Morteza, Hassan Esmaceli-Gisavandani, and Arash Adib. "Drought monitoring and prediction using SPI, SPEI, and random forest model in various climates of Iran." *Journal of Water and Climate Change* 13.2 (2022): 383-406.
- Mallya, G., Mishra, V., Niyogi, D., Tripathi, S., & Govindaraju, R. S. (2016). Trends and variability of droughts over the Indian monsoon region. *Weather and Climate Extremes*, 12, 43-68.
- McKee, T. B., Doesken, N. J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. In *Proceedings of the 8th Conference on Applied Climatology*, 17(22), 179-183.
- Pai et al. (2014). Pai D.S., Latha Sridhar, Rajeevan M., Sreejith O.P., Satbhai N.S. and Mukhopadhyay B., 2014: Development of a new high spatial resolution (0.25° X 0.25°) Long period (1901-2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region; *MAUSAM*, 65, 1(January 2014), pp1-18.
- Pai, D. S., Guhathakurta, P., Kulkarni, A., & Rajeevan, M. N. (2017). Variability of meteorological droughts over India. *Observed climate variability and change over the Indian Region*, 73-87.
- Poornima, S., & Pushpalatha, M. (2019). Drought prediction based on SPI and SPEI with varying timescales using LSTM recurrent neural network. *Soft Computing*, 23, 8399-8412.
- Rehana, S., & Naidu, G. S. (2021). Development of hydro-meteorological drought index under climate change–Semi-arid river basin of Peninsular India. *Journal of Hydrology*, 594, 125973.
- Shrivastava, S., Kar, S. C., Sahai, A. K., & Sharma, A. R. (2018). Identification of drought occurrences using ensemble predictions up to 20-days in advance. *Water resources management*, 32, 2113-2130.
- Tirivarombo, S. O. D. E., D. Osupile, and Peter Eliasson. "Drought monitoring and analysis: standardised precipitation evapotranspiration index (SPEI) and standardised precipitation index (SPI)." *Physics and Chemistry of the Earth, Parts A/B/C* 106 (2018): 1-10.
- Udmale, P., Ichikawa, Y., Ning, S., Shrestha, S., & Pal, I. (2020). A statistical approach towards defining national-scale meteorological droughts in India using crop data. *Environmental Research Letters*, 15(9), 094090.

--Dr. Prasanna Kumar K R  
Associate Professor  
Department of Geography  
Government First Grade  
Vijayanagar, Bangaluru  
(Karnataka)



## **FLUVIO-GEOMORPHOLOGICAL STUDY ON HYDROGRAPH AND FLOOD FREQUENCY ANALYSIS OF PAGLADIYA RIVER IN ASSAM**

Dr. Dipak Baruah and Dr. Safiqur Rahman

### **Abstract**

The Pagladiya River is considered as one of the most important source of hydrological inputs for the mighty Brahmaputra river. The spatio-temporal variation in terms of the discharge volume and impact of flood of this river are determined by various factors. The frequent disastrous flood impacts of this river are mostly common in the adjacent areas of Nalbari District of Assam affecting the academic atmosphere, the agrarian economy and existing infrastructural facilities. The ongoing variation and fluctuation in the nature of flood as well as the impact of flood in this area needs proper study and analysis on some aspect pertaining to nature, frequency, probability and magnitude of flooding. The present paper assumes much significance in understanding the fluctuations of discharge and flood estimation of the river Pagladiya. The record of annual flood series of the Pagladiya river at N. T. Road crossing site for the duration of twenty three years (2004 to 2017) has been analyzed to examine the annual discharge fluctuation and probability of flood occurrence using the Weibulls' Plotting Position and Gumbel's Extreme Value Distribution Methods.

### **Introduction**

The hydrographs and flood frequency analysis of any river provide valuable data base for the purpose of hydrologic analysis. Hydrologic response leads to assessment of the potential of water resource in a watershed (1). At a given gauge site, the stage (WL) and water discharge (Q) vary from year to year and their magnitudes constitute a hydrologic data series to assign a frequency of a given flood-peak value. The flood in a catchment depends upon the nature of the catchment, rainfall and other conditions which are in turn dependent on a lot of constituent parameters. Ingle B Nilesh, 2022 had emphasized more on the quantitative analysis of morphometric parameters is of immense utility in river basin evaluation, watershed prioritization for soil and water conservation and natural resources management at micro level (2). This investigation will assist in further study for forecasting

floods and preparing safety design as a mitigation strategy for flood hazard in the study area. The present study may provide an important strategy to the flood hazard management approaches in case of the Pagladiya river basin.

### **Study Region**

Pagladiya is an important tributary on the north bank of the Brahmaputra River. It has its source near the India– Bhutan border where the river debouches in to the plains at latitude  $26^{\circ}48'$  and Longitude  $91^{\circ}28'$  (3). The study area lies between  $91^{\circ}19'41.097''\text{E}$  to  $91^{\circ}34'45.757''\text{E}$  longitude and  $26^{\circ}27'26\text{ N}$  to  $27^{\circ}0'9.289''\text{ North}$  latitude. Major portion of the study area lies within the state of Assam and a small patch of the upper reach lies in the Bhutan. Elevation map derived from the DEM revealed that altitude in the watershed ranges from 45 m (MSL) to 2340 m (MSL). The average slope of the watershed varies from 3% to 50% with maximum area under the slope between 2% to 15 % (4).

### **Objectives**

- (1) To assess the pattern of fluctuations of stage and discharge represented by the hydrographs for Pagladiya river and
- (2) To estimate the probability of flood occurrence by using Plotting Position and Gumbel's Extreme Value Distribution method.

### **Database and Methodology**

The data base for this paper is mainly based on the data collected from secondary sources. viz, (i) Survey of India (SOI) toposheets and (ii) Discharge data from Water Resource Department. One set of hydrologic data of annual peak discharge data for 2004 to 2017 of the river have been used for the preparation of hydrographs and flood occurrence probability analysis. For this purpose, the method of Plotting position and Gumbel's Extreme Value Distribution has been used. The methodology for this piece of research work has been followed as per the following flow chart (**Fig. 1**).

### **Result and Discussion**

#### **Hydrograph Analysis**

A hydrograph is a graph showing the rate of flow versus time in a river or other channel. The rate of flow is typically expressed in cubic meters or cubic feet per second. The hydrograph is the response of a given catchment to a rainfall input (5). The volume of water discharge is highly correlated with the bank erosion events in most of the rivers.

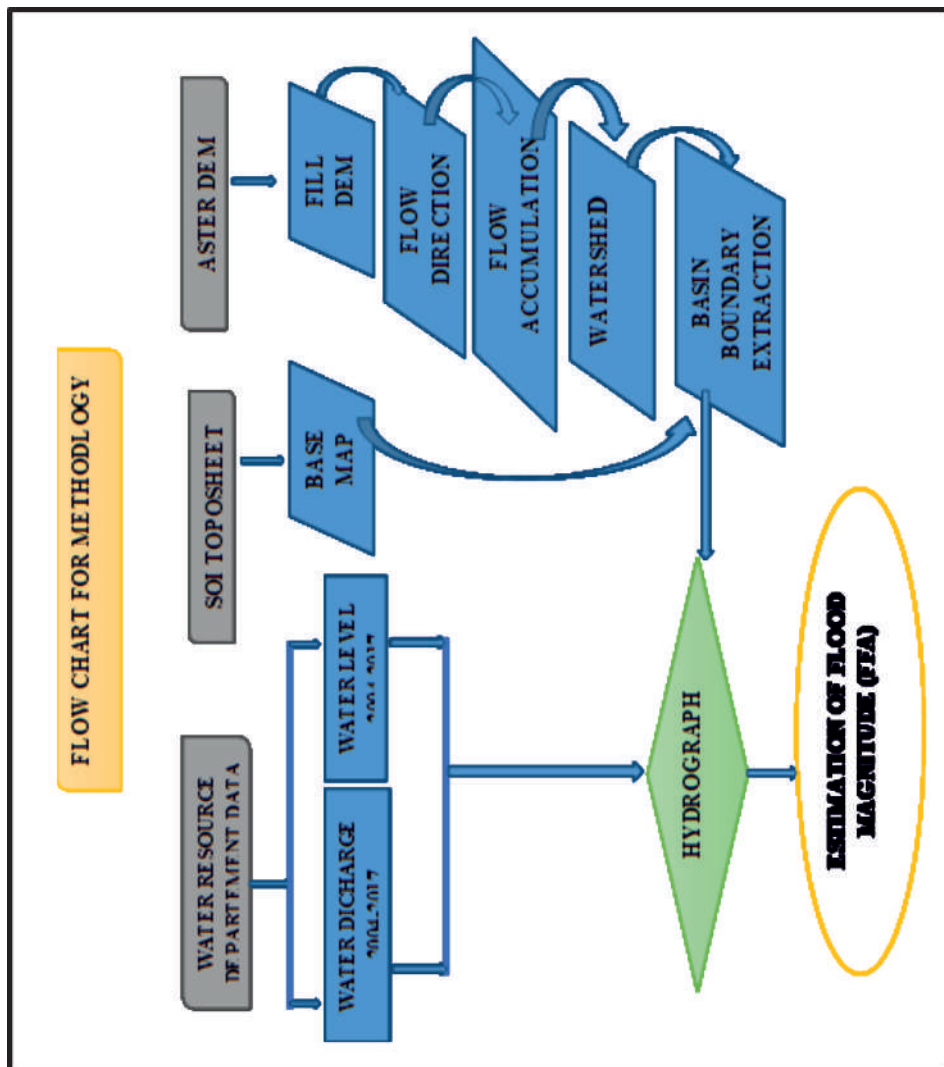


Fig. 1

In the monsoonal rivers, high magnitudes floods occur at an interval of several years to decades. Peak discharges are two to four times more than the mean monsoon discharges (6). Besides the recorded data of water resource department, now a days, most of the authors use geospatial techniques to assess the NDWI to have better understanding the water potentiality of any river basin. With the improvement of satellite resolution, the information abundance carried by remote sensing image increases, and the identification of water boundary is more accurate (7). For the entire paper, the analysis of stage discharge fluctuation and hydrograph has been done under the following headings.

### Fluctuation of Monsoonal stage and discharge (2013-2017)

The climatic change is considered as the important influential factor for the fluctuation of stage and water discharge of any river. It is very much easy to observe the frequent change of stage in a river cross section but observation of water discharge needs measurement of other relevant parameters like depth and velocity (8). The water level and discharge of any river as well as surface runoff of the entire river basin has its close relation with the pattern of dissection. The spatial distribution of dissected indices for any basin reflects the lithologic, structural and allied characteristics of terrain (9). The variation of stage and discharge for the monsoonal period for Pagladiya River has been represented in Fig. 1 and **Table-1**.

Table-1: Stage Discharge of Monsoonal Period for Pagladiya River (2013-2016)

Year & Month	2013		2014		2015		2016	
	Stage (m)	Discharge m <sup>3</sup> /s(Q)	Stage (m)	Discharge m <sup>3</sup> /s(Q)	Stage (m)	Discharge m <sup>3</sup> /s(Q)	Stage (m)	Discharge m <sup>3</sup> /s(Q)
May	51.04	18.06	51.33	42.42	50.61	73.14	51.34	53.39
June	51.45	75.26	51.44	73.81	51.88	311.8	51.75	184.61
July	51.53	79.83	51.67	167.4	51.99	119.25	52.41	226.62
Aug	50.97	36.22	51.8	105.88	51.95	228.88	51.41	69.61
Sept	52.4	195.85	52.6	243.07	52.55	253.58	52	165.24
Oct	50.61	20.46	-	-	51.14	48.16	51.7	65.2

Source: Water Resource Department, Govt. of Assam

**Table-1** reveals that in the year 2013 monsoonal maximum stage discharge values are found in September month and minimum stage discharge values are found in September and May month. In the year 2014, the highest and lowest values for monsoonal maximum stage discharge is in September month and minimum in August and May month. In the year 2015 monsoonal maximum stage discharge is found in September and June month and Minimum stage discharge in May and

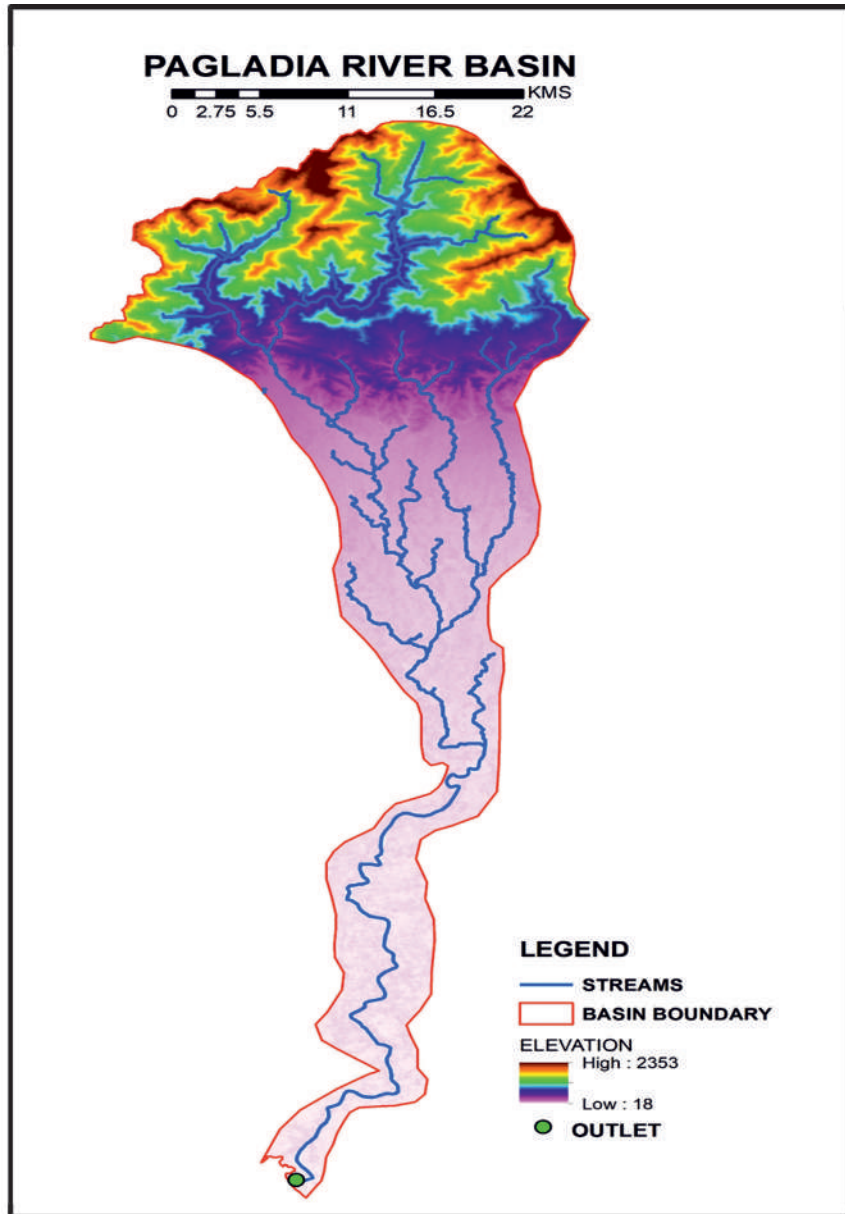


Fig. 2

October month. In the year 2016 the monsoonal maximum stage discharge is found in July month and minimum is in October month.

### Annual Maximum Stage Discharge Hydrograph (2004-2017)

In hydrology, the term “peak discharge” stands for the highest concentration of runoff from the basin area (10). During the period of May to October the highest rainfall occurs in every year over the entire Pagladiya river basin. The **Table-2** and **Fig. 1** reveal that the river Pagladiya has the record of maximum annual water level & discharge in N.T. road crossing has been noticed in the year 2004 (54.44 m and 495 cumec) during the last 14 years (2004-2017) (**Table-2**). Due to heavy rainfall in the year 2004 the Pagladiya came out with a devastating flood in that year. **Table-2** represent the fluctuation of maximum stage discharge in year between 2004-2017.

Table-2: Annual Maximum Stage Discharge for Pagladiya River (2004-2017)

year	Maximum water level in meter	Peak Water Discharge in cumec	year	Maximum water level in meter	Peak Water Discharge in cumec	year	Maximum water level in meter	Peak Water Discharge in cumec
2004	54.44	495	2009	52.1	53	2014	52.6	243.07
2005	53.78	426	2010	52.75	189	2015	52.55	253.58
2006	52.84	299	2011	51.71	132.37	2016	52.4	226.02
2007	52.69	243	2012	53.37	316.35	2017	52.9	335.39
2008	53.35	353	2013	52.4	79	-	-	-

Source: Authors

### Annual Average Discharge

Flood discharge estimates are required for a variety of purposes including the design and appraisal of reservoir and irrigation schemes, flood management projects and river rehabilitation and restoration initiatives (11). The entire Pagladiya river stretch is generally perennial. The average discharge of Pagladiya river as per the master plan of Brahmaputra Board is 1737.00 Cumec. It is also observed that even during the dry season, the river maintains 50% of the average flow recorded. The high volume of discharge and water level of the river can be great use for good irrigation practices for the people. The following **Table-3** and **Fig. 2** reveal that the river Pagladiya has maximum annual average discharge was recorded in the year 2004 (150.78 cumec) and minimum average discharge was recorded in the year 2014 (32.07 cumec) (**Table-3**).

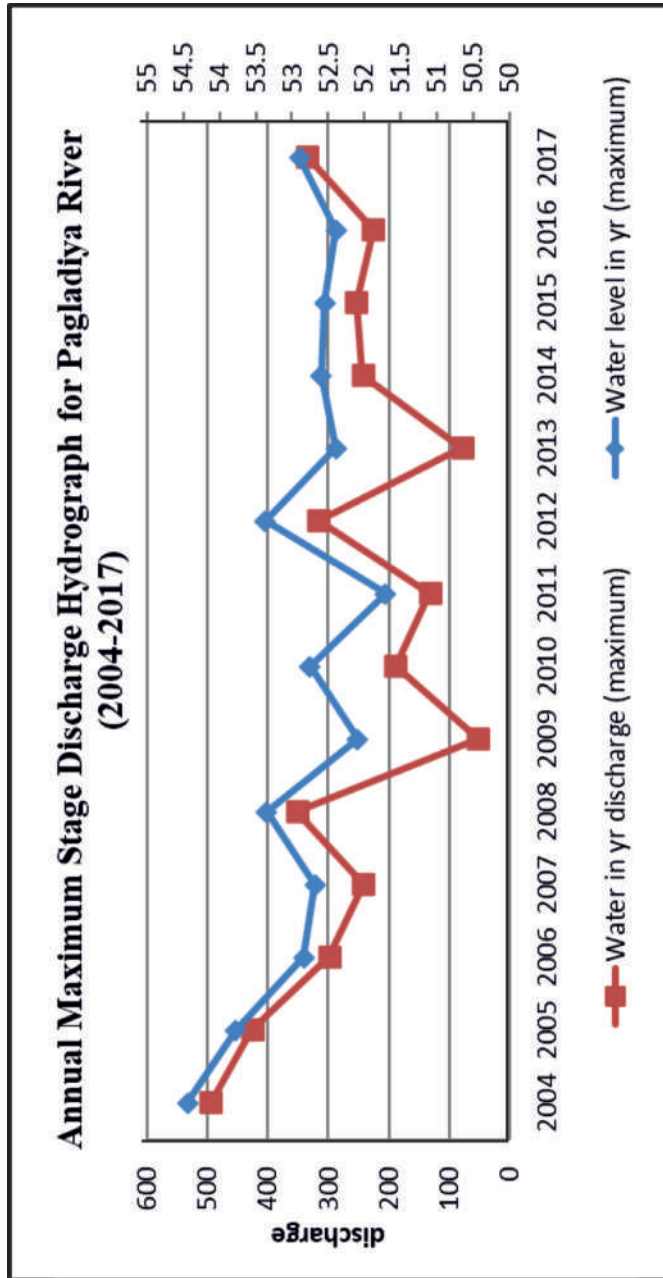


Fig. 3

Table-3: Annual Average Discharge for Pagladiya River  
at N. T. Road Crossing Site (2004-2017)

Year	Average Water discharge in cumec	Year	Average Water discharge in cumec	Year	Average Water discharge in cumec
2004	150.78	2009	42.205	2014	33.64
2005	135.76	2010	75.23	2015	32.071
2006	103.235	2011	61.125	2016	90.195
2007	90.37	2012	106.13	2017	113.27
2008	119.61	2013	33.071	-	-

Source: Authors

### Flood Frequency Analysis

Flood frequency Analysis is a technique used by hydrologist to predict flow values corresponding to specific return periods or probabilities along a river. Flood frequency analysis (FFA)—estimating the probability distribution of peak flows—is a common practice in hydrology. It plays a central role in engineering design, floodplain mapping, river restoration, and the assessment of ecosystem services along river corridors (12). Kumar et al. (2003) have carried out the regional flood analysis for estimation of floods of various return periods for gauged and ungauged catchments of the North Brahmaputra River system (13). Design flood estimation is a fundamental task in hydrology (14). The application of statistical Frequency curves to flood was first introduced by Gumbel. Using annual peak flow data that is available for a number of years, Flood Frequency Analysis is used to calculate statistical information such as mean, standard deviation and skewness which is further used to create frequency distribution graphs. These graphs are then used to estimated the design flow values corresponding to specific return period which can be used for Hydrologic planning purposes (**Fig. 4**). The estimation of discharge of a stream is the outmost important prerequisite for any engineering and geological project (15). Pandey and Ramasastrri (2003) studied low flows in San and Barah rivers, tributaries of Indravati river system in Orissa using weekly flow data from two gauging sites (16). Flood frequency plays a vital role in providing estimated of recurrence of floods which is used in designing structure such as dams, bridges, culverts, levees, highways, etc. Majority of river basins are either sparsely gauged or not gauged at all, where the lack of hydrological and catchment information

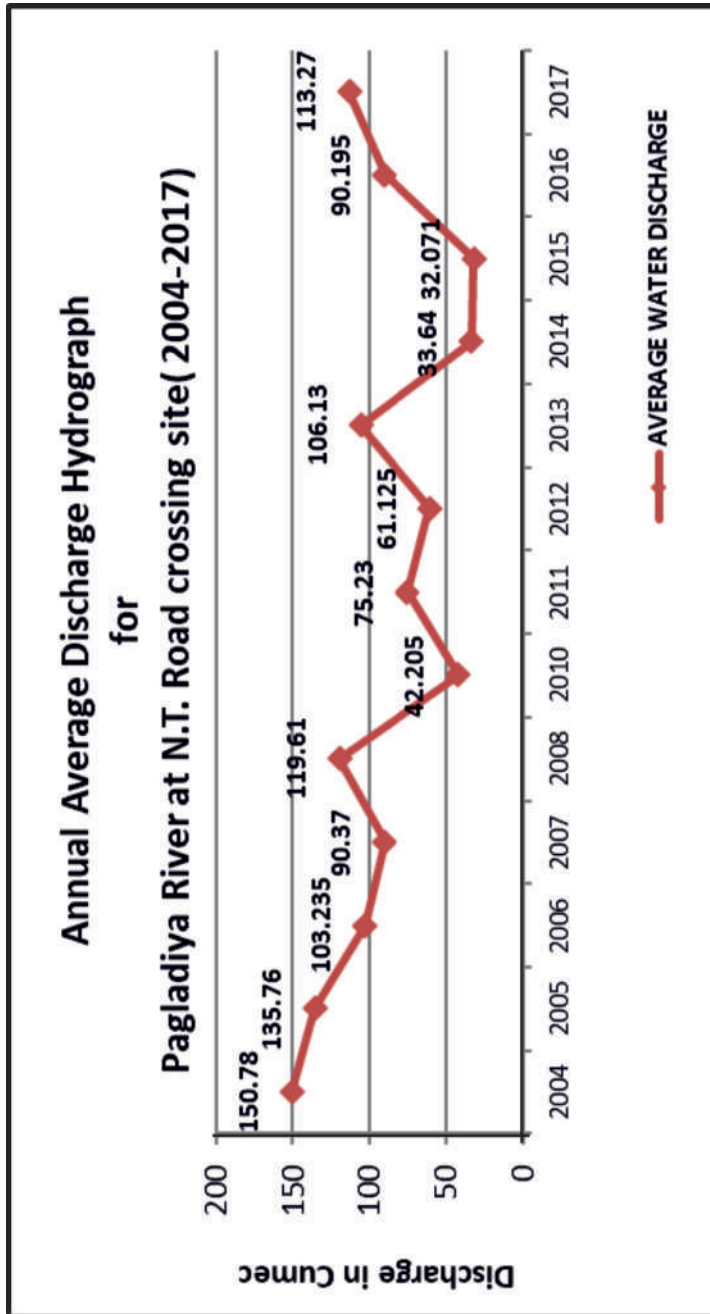


Fig. 4

makes obstruction for watershed planning (17). Estimating stream flow has a substantial financial influence, because this can be of assistance in water resources management and provides safety from scarcity of water and conceivable flood destruction (18). In order to understand how flood frequency analysis works, it is essential to understand the concept of return period. Return period is an inverse of the probability that an event will be exceeded in a given year. Return period are used to convey the risks of rare events more effectively than simply starting the probabilities.

### Plotting Position Method

Plotting order-ranked data is standard technique that is used in estimating the probability of extreme weather events. The annual extreme flood of a period of  $N$  years, are ranked in order of magnitude and the plotted on probability paper. Some statistical model is then fitted to the order ranked data by which the return periods of specific extreme events are estimated. Here, it is shown that in estimating the return period there is only one correct plotting position:  $p=m/(n+1)$ . This formula predict must shorter return period of extreme events than the other commonly used method. In the following table we can apply this method in Pagladiya River. The river Pagladiya river in estimated peak flood (2004-2017) Using weillbull's plotting Method we can found in ordinary plotting the return period of 20 years is peak flow will be 500 cumec and for 30 years return period of peak flow will be 595 cumec (**Table-4**). The flood frequency curve is used to relate flood discharge values to return period to provide an estimate of intensity of flood event.

Table-4: Estimated Peak Flood of Pagladia River (2004-2017)

Sl. No	Year	Discharge(Q)	Discharge in descending order	Order(m)	Tr=(n+1)/m
1	2004	495	495	1	15
2	2005	426	426	2	7.5
3	2006	299	353	3	5
4	2007	243	335.39	4	3.75
5	2008	353	316	5	3
6	2009	53	299	6	2.5

Contd...

7	2010	189	253	7	2.1428
8	2011	132.37	243.07	8	1.875
9	2012	316.35	243	9	1.6666
10	2013	79	226.02	10	1.5
11	2014	243.07	189	11	1.3
12	2015	253.58	132	12	1.25
13	2016	226.02	79	13	1.1536
14	2017	335.39	53	14	1.0714

Source: Authors

### Gumbell's Extreme Value Distribution Method

This extreme value distribution was introduced by Gumbel (1941) and is commonly known as Gumbel's distribution. It is one of the most widely used probability-distribution functions for extreme values in hydrologic and meteorologic studies for prediction of flood peaks, maximum rainfall, maximum wind speed, etc. Gumbel defined a flood as the largest of the 365 daily flows and the annual series of flood flows constitute a series of largest values of flows. Gumbel's distribution is one of the statistical approaches that is mostly used to analyze flood data. It is also used to predict hydrological events such as flood. If a flood peak in the main river is superimposed by a simultaneous peak from a tributary, the magnitude of the flood peak may be increased significantly downstream. Conversely, a temporal offset of both flood waves may result in a substantial increase in volume but only a moderate increase of the peak downstream (19 & 20). The flood frequency analysis is a multivariate statistical method for predicting the frequency of flooding and this is determined by discharge information (21) (**Table-5 and 6**). The estimation of flood magnitude has been carried out for the river Pagladiya using another method i.e. Gumbel's distribution which is one of the best probability distribution methods used to model stream flow. Gumbel's distribution was used to model the annual maximum discharge of the Pagladiya river for a period of 14 years (2004-2017) of flood data. Table 5 (a, b) and **Fig. 4** reveal that for the return period of 25 years and 50 years, the expected estimated discharge is 340 cumec and 370 cumec respectively. These values are useful for hydrological management in the study area.

Table-5: Estimated Peak Flood of Pagladia River (2004-2017)

Sl. No.	Year	Discharge (Q)	Discharge In descending order	Order (m)	Tr= $((n+1)/m)$	Reduced variated (yt)
1	2004	495	495	1	15	2.6737
2	2005	426	426	2	7.5	1.944
3	2006	299	353	3	5	1.499
4	2007	243	335.39	4	3.75	1.170
5	2008	353	316	5	3	6.9027
6	2009	53	299	6	2.5	0.6717
7	2010	189	253	7	2.1428	0.8541
8	2011	132.37	243.07	8	1.875	0.2716
9	2012	316.35	243	9	1.6666	0.0765
10	2013	79	226.02	10	1.5	-0.0940
11	2014	243.07	189	11	1.3	-0.3827
12	2015	253.58	132	12	1.25	-0.475
13	2016	226.02	79	13	1.1536	-0.7012
14	2017	335.39	53	14	1.0714	-1.002

Source: Authors

Table-6: Estimated Peak Flood of Pagladia River (2004-2017)

Return period	Reduced return period (yt)	$\bar{x}$	Sd	$\bar{y}_n$	Sn	Kt=(yt-yn)/Sn	Xt= $\bar{x}+kt.sx$
2	0.3665	260.27	31.985	0.5100	1.0095	-0.1387	255.8336
5	1.4999					0.994	292.063
10	2.2504					1.7451	316.087
20	2.9702					2.4649	339.1098
25	3.1985					2.693	346.4056
50	3.9019					3.396	368.891
100	4.6001					4.094	391.216
200	5.2958					4.790	413.478

Source: Authors

## **Conclusion**

The maximum and maximum stage discharge values for monsoonal season for the considered duration (2013-2016) are found in the month of September May. In the year 2014, the highest and lowest values are observed in the month of September and minimum one is in August and May month. In the year 2015 monsoonal maximum stage discharge maximum value is found in September and June and Minimum one is observed in May and October month. In the year 2016 the maximum value is found in July month and minimum is in October month. The record of maximum annual water level & discharge in N.T. road crossing has been noticed in the year 2004 (54.44 m and 495 cumec) during the last 14 years (2004-2017). The river Pagladiya had maximum annual average discharge in the year 2004 (150.78 cumec) and minimum average discharge in the year 2014 (32.07 cumec). Using Weibull's plotting Method, the estimation of peak flood has been done for this river of the duration of 14 years (2004-2017) and the return period 20 and 30 years has been considered where peak flow will be 500 cumec and 595 cumec. Gumbel's extreme value distribution method has been used to estimate the peak flood for the return period of 25 years and 50 years, the expected estimated discharge is 340 cumec and 370 cumec respectively. After brief discussion through the various chapters, topics of this paper "A FLUVIO-GEOMORPHOLOGICAL STUDY ON SOME HYDROGRAPH AND FLOOD FREQUENCY ANALYSIS OF PAGLADIYA RIVER, ASSAM, INDIA" have to conclude. While conducting the present work, it is perceived that the problems seem to be very simple in appears but too complex in nature. This study identifies the problems and carries out right decision of flood and assessment of identification problems.

## **References**

- Khusuwaha NL & Bhardwaj A – "Hydrologic response of Takaria- Ballawal watershed in Shivalik foot hills based on morphometric analysis using RS & GIS, J Indian water resource society, 2016.
- Ingle B Nilesh, 2022 : Morphometric analysis of Morna River sub basin using geospatial approach , International Journal of Multidisciplinary Research and Development, Online ISSN: 2349-4182, Print ISSN: 2349-5979, Volume 9, Issue 1, 2022, Page No. 71-78
- Sarma, J. N. (2008): Asamar Nad-Nadi, Assam Sahitya sabha, Kiran Prakashan, Dhemaji, Assam.
- Talukdar Kumar Kamal. IJRASET, vol. 7 issue VII, July 2019... Watershed Characteristics of Pagladiya River using GIS and Digital Elevation Model
- Subramanya K (1997), "Engineering Hydrology", Second Edition, pp 181 – 270 , published by Tata McGraw-Hill Publishing Company Limited, New Delhi.

- V S Kale, 1998: Monsoon floods in India: A hydrogeomorphic perspective
- Yanan Qi et al 2022: An Adaptive Threshold Selected Method from Remote Sensing Image based on Water Index, Journal of Physics: Conference Series, Open access paper
- <https://nhp.mowr.gov.in> – Hydrology project on Understanding stage discharge relation (pp 7-8)
- Kumar, A., and Pandey, R. N. (1981). Morphometric Analysis of Some Drainage Basins of the Hazaribagh Plateau Region. *Natl. Geographical. J India* 27 (Part 1and 2), 50–57.
- Roy Suvendu and Mistri Biswaranjan. Research Article on Estimation of Peak Flood Discharge for an Ungauged River: A Case Study of the Kunur River, West Bengal
- Wharton G. & Tomlinson J. J, 1999... ‘Flood discharge estimation from river channel dimensions: results of applications in Java, Burundi, Ghana and Tanzania’ *Hydrological Sciences—Journal—des Sciences Hydrologiques*, 44(1) February, pp.97
- Hansli, E. (2012). Possible impacts of floods and droughts on water quality. *Journal of Hydro-environment Research*, 6, 145–150. <https://doi.org/10.1016/j.jher.2012.01.008>
- Kumar, R.; Chatterjee, C.; Panigrihy, N.; Patwary, B. C.; Singh, R. D. 2003. Development of Regional Flood Formulae using L-moments for Gauged and Ungauged Catchments of North Brahmaputra River System. *The Institutions of Engineers (India)* 84: 57-63.
- Gang Zhao, Paul Bates, Jeffrey Neal and Bo Pang. Design flood estimation for global river networks based on machine learning models. *Hydrology and Earth system science*
- Hussain T. A.2017 – Discharge estimation of Disang River, Assam for Micro hydropower & diversion based Irrigation Project, *Imperial Journal of Interdisciplinary Research (IJIR)*, Vol-3, Issue-10, 2017.
- Pandey, R. P.; Ramasastri, K. S. 2003. Estimation of lean season water availability in streams with limited data. *The Institution of Engineers (India)* 84: 149-152.
- V. K. Bhatt and A. K. Tiwari, “Estimation of peak streamflows through channel geometry,” *Hydrological Sciences Journal*, vol.53, no. 2, pp. 401–408, 2008].
- Samantaray Sandeep and Sahoo Abinas. Estimation of flood frequency using statistical method: Mahanadi River basin, India, *H2Open Journal* Vol 3 No 1, 189doi:10.2166/h2oj.2020.004.//iwaponline.com/h2open/article-pdf/3/1/189/863310/h2oj0030189.pdf
- Blöschl, G., Nester, T., Komma, J., Parajka, J., & Perdigão, R. A. P. (2013). The June 2013 flood in the Upper Danube Basin, and comparisons with the 2002, 1954 and 1899 floods. *Hydrology and Earth System Sciences*, 17, 5197–5212. <https://doi.org/10.5194/hess-17-5197-2013>
- Skublics, D., Bloeschl, G., & Rutschmann, P. (2016). Effect of river training on flood retention of the Bavarian Danube. *Journal of Hydrology and Hydromechanics*, 64, 349–356. <https://doi.org/10.1515/johh-2016-0035>

Dr. Dipak Baruah  
Assistant Professor  
Bhattadev University  
Barpeta  
Kamrup (Assam)

Dr. Safiqur Rahman  
Assistant Professor  
Guwahati College  
Bamunimoidam, Guwahati  
Kamrup (Assam)



## **SPATIO-TEMPORAL CHANGES IN VEGETATION COVER OF THE MAJHUEE RIVER BASIN IN PHOOLPUR TEHSIL IN AZAMGARH DISTRICT**

Shivam Singh and Ashwajeet Chaudhary

### **Abstract**

Vegetation cover dynamics are vital for evaluating eco-environmental changes, acting as a natural link between the atmosphere, water, and soil. As the core foundation of terrestrial ecosystems, vegetation's condition is crucial. This study assesses the vegetation status in the Majhuae river basin, Phoolpur tehsil, using Landsat 5 and Landsat 8 datasets from 1990 and 2022, respectively. The NDVI method has been used to examine the spatio-temporal changes in vegetation cover over this period. The results indicate a substantial increase in built-up areas and road network density in 2022, with dense vegetation in the river basin expanding from 27% of the basin area in 1990 to 86% in 2022. Field surveys validated the increasing trend in vegetation, primarily driven by the expansion of cropland, which has replaced natural vegetation due to urbanization. This vegetation growth results from intensified agricultural activities and advanced agricultural technologies. This study offers valuable insights for sustainable land use planning and environmental conservation in Phoolpur tehsil.

### **Introduction**

Terrestrial vegetation, which covers a substantial portion of the Earth's surface (Bonan et al., 1992), plays a critical role in urban planning, particularly as the focus increasingly shifts toward enhancing the quality of the urban environment. Urban planning today encompasses various elements such as housing, services, employment, the natural environment, and social and cultural concerns related to urban landscape preservation. The geographical location, socio-economic structure, and spatial arrangement of man-made structures are crucial elements of this planning process. Urban vegetation contributes significantly to these areas by managing vegetation within urban spaces to benefit the urban population (Bithas & Christofakis, 2006). Urban vegetation exists in two primary environments: the horticultural or garden habitat and the forest habitat.

Both serve vital environmental purposes within settlements (Jorgensen, 1977). Trees, due to their size and durability, predominate in both habitats, offering recreational and aesthetic benefits that enhance the physical and emotional health and general well-being of residents. The primary differences between these habitats lie in their management needs, land requirements, and environmental impacts (Willis et al., 2018). Despite these differences, the recreational and aesthetic values provided by urban vegetation are essential for community health and positively influence the ecology of habitation (Dhinwa et al., 1992). Vegetation acts as a pollution sink, reducing air and noise pollution, and supports interactions between humans and the local wildlife population (Miller et al., 2015). The existing vegetation within and around settlements is diverse and varied, including urban vegetation, rangelands, wetlands, and forests. Conservation of valuable remnants of natural forests and urban horticultural plantings should be prioritized (Jensen, 2009). Spatiotemporal monitoring of terrestrial vegetation is essential for researching various terrestrial resource management uses, highlighting the importance of effectively preserving and managing these habitats. This monitoring addresses vegetation management for the urban population and within the urban environment. Vegetation cover near water basins plays a crucial role in maintaining ecological balance and ensuring the sustainability of water resources.

The presence of vegetation in these areas is essential for several reasons, including water quality improvement, soil erosion control, wildlife habitat, and maintaining local climate conditions (Ling et al., 2019). In this context, using remote sensing technology for vegetation mapping has become increasingly important. Remote sensing offers a comprehensive and efficient means of monitoring and managing these vital ecosystems (Lawley et al., 2016). The presence of vegetation near water basins significantly enhances the natural hydrological cycle, promoting groundwater recharge and reducing the risks of floods and droughts (Ren et al., 2022). Maintaining healthy vegetation ensures a reliable and sustainable water supply for agricultural, industrial, and domestic use, benefiting communities economically (Liu et al., 2022). Additionally, vegetated areas near water bodies offer valuable recreational opportunities, such as hiking, bird watching, and fishing, and provide aesthetic value that contributes to local residents' well-being and quality of life (Schirpke et al., 2016). For several reasons, studying the vegetation near the Majhuee River in the Phoolpur tehsil of Azamgarh is essential. The vegetation cover in this area plays a pivotal role in maintaining ecological balance and enhancing agricultural productivity, which is the primary livelihood for the local population. It helps control soil erosion, preserve soil fertility, and

support the local hydrological cycle, which is crucial for sustainable agriculture. Furthermore, understanding the vegetation dynamics can inform effective land use and conservation strategies, ensuring the long-term health of the ecosystem. This research is vital for increasing the community's resilience to environmental challenges such as climate change and extreme weather events.

### **Study Region**

The Majhuee River, a significant tributary of the Tamsa River, flows through the Phoolpur Tehsil of Azamgarh district in Uttar Pradesh, India. The study area is located at geographic coordinates of 26.079774°N and 82.314093°E. Phoolpur Tehsil is at an average elevation of 81 meters (265 feet) above sea level. The area's topography and climatic conditions play a crucial role in the hydrological patterns observed in the Majhuee River. The river's flow and seasonal variations significantly impact local agriculture, water supply, and ecosystem health. The Majhuee River, water are essential for irrigation, contributing to the agricultural productivity of the region. Additionally, the river helps recharge the groundwater levels, ensuring a sustainable water supply for the local population.

### **Objective**

This paper aims to analyze the vegetation dynamics along the Majhuee river in Phoolpur Tehsil of Azamgarh district using remote sensing data.

### **Database and Methodology**

In this study, multi-temporal satellite imagery from the Landsat series, satellite of Landsat 5 and Landsat 8, was used to map vegetation cover around the basin. Additionally, field surveys were conducted during different crop seasons in 2021 and 2022 to ground truth the NDVI results. The satellite data details are presented in **Table-1**.

Table-1: Satellite Data

S.No.	Satellite	Description of satellite	Resolution	Date of acquisition
01	Landsat 5	LANDSAT/LT05/C02/T1_TOA/ LT05_142042_19900315	30 m	15-03-1990
02	Landsat 8	LANDSAT/LC08/C02/T1_TOA/ LC08_142042_20220323	30 m	23-03-2022

Source: Authors

The Normalized Difference Vegetation Index (NDVI) is a commonly used remote sensing technique to help identify vegetation and measure its health and vitality. The presence of chlorophyll and photosynthesis causes light absorption in the RED region of the Spectrum. In contrast, vegetation's internal cellular structure or biomass can be indicated in the NEAR INFRARED (NIR) region. In general, healthy and dense vegetation reflects a lot of NIR light but very little RED as it is absorbed instead. Conversely, when vegetation is sparse or unhealthy, we see a decrease in the NIR reflectance but an increase in the RED reflectance as there is less chlorophyll to absorb the RED light. The NDVI combines the information available in the RED and NIR bands into a single representative value. It does this by subtracting the reflectance in the RED spectral band from that in the NIR and dividing this by the sum of the NIR and RED reflectance. The negative(-) sign in the numerator ensures that regardless of the NIR and RED values, the numerator will always calculate out to a value less than that of the denominator. This means that the value of the NDVI will always equate to a value between (-) 1 and (+) 1.

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red}) \dots\dots\dots \text{Equation (i)}$$

Using near-infrared (NIR) and visible red (R) light, the Normalized Difference Vegetation Index (NDVI) is created to assess the presence of a single band normalized vegetation index by collecting vegetation. Digital number (DN) and various band values are needed to calculate NDVI. A digital numeric value is generated from these pixel bands (Singh, 1986). For Landsat 5, data NDVI is computed using the following formula:

$$\text{NDVI} = (\text{Band 4} - \text{Band 3}) / (\text{Band 4} + \text{Band 3}) \dots\dots\dots \text{Equation (ii)}$$

For Landsat 8, data NDVI is computed using the following formula:

$$\text{NDVI} = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4}) \dots\dots\dots \text{Equation (iii)}$$

Healthy vegetation (chlorophyll) reflects near-infrared (NIR) and green light more than other wavelengths. But it absorbs more red and blue light (Zahir et al., 2022). Healthy dense vegetation has high NIR and low RED reflectance values, such that the NIR value dominates the NDVI equation. The NDVI will, therefore, tend towards a positive one (+1). The less healthy vegetation has more dominance of RED reflectance, decreasing the overall NDVI value but will remain positive (+). While NDVI is primarily used for vegetation, it can also help identify other features in an image as well. For example, water has a very distinctive NDVI as almost all NIR light is absorbed by water, so the RED reflectance value becomes higher than the NIR. This, therefore, sets up a situation where the numerator becomes negative (-), and the NDVI value is also negative (-) or less than zero.

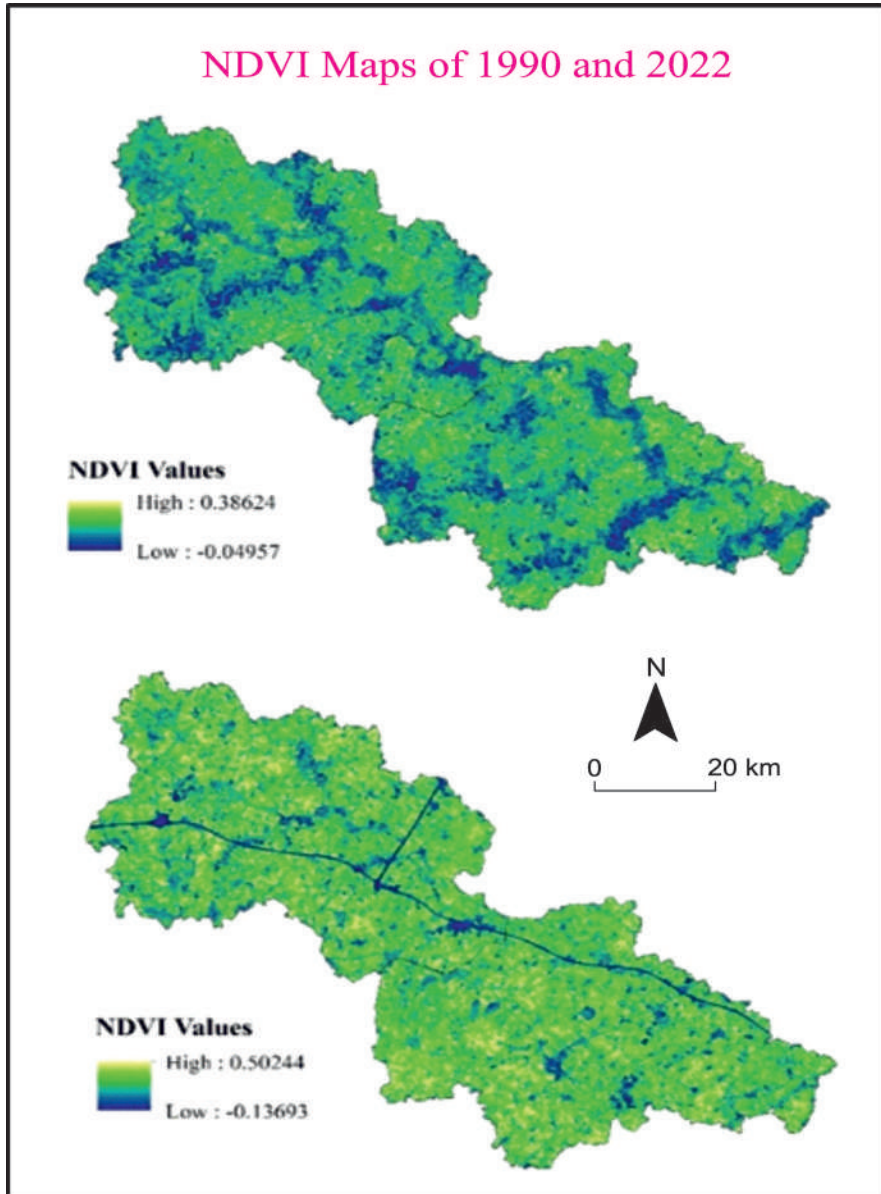


Fig. 1

## Result and Discussion

Vegetation cover dynamics can be used as an indicator to evaluate eco-environmental change. Vegetation is a natural link between the atmosphere, water, and soil. Vegetation is the core foundation of the terrestrial ecosystem. As a result, vegetation is crucial to the energy exchanges, biogeochemical cycles, and hydrological cycles at the surface of the Earth (Piao et al., 2003). Global change studies are interested in temporal and spatial variations in vegetation cover because these variations are significant markers of changes in the local biological environment (Fabricante et al., 2009). Understanding vegetation responses to climate change, human activity, and the evolution of the regional biological environment depends critically on the dynamic monitoring of plant cover change (Mao et al., 2011). This work assessed the vegetation condition in the Majhuee river basin in Phoolpur tehsil using Landsat 5 and 8 datasets for 1990 and 2022, respectively. In 1990, the NDVI ranged from 0.38624 to -0.04957. The higher values (positive values) indicate the amount of greenery in the region, whereas the negative values indicate the water and barren land. The NDVI maps are presented in **Fig. 1**. In 2022, NDVI computation ranges from 0.51244 to -0.13693. The increase in built-up areas is visible in small patches, and the surge in road network density can easily be seen in the NDVI image 2022, which is a dark green colour. It was observed that dense vegetation increased from 1990 to 2022, which is indicated by light green patches in NDVI outputs. Therefore, vegetation mapping was done using NDVI outputs to examine the spatio-temporal change in vegetation cover in Phoolpur. The vegetation cover status is presented. The status of vegetation cover in Phoolpur tehsil was generated by the NDVI output thresholding method. From the NDVI outputs, a vegetation map has been generated using the thresholding method. The vegetation cover map is classified into three categories: Dense Vegetation, Sparse Vegetation, and Other. Dense vegetation represents healthy vegetation cover, Sparse Vegetation indicates scrubland, and the other category includes water bodies, built-up areas, open lands, etc.

In 1990, dense vegetation accounted for 27% of the basin's area. The vegetation around the basin was relatively sparse and dominated by natural vegetation. However, by 2022, vegetation cover was significantly increased around the basin, rising to 86%. This surge is attributed to expanding agricultural activities and substantial technological and mechanization advancements (**Fig. 2**). Detailed vegetation cover statistics are presented in **Tables-2**. Field surveys conducted during different crop seasons revealed changes in vegetation cover, specifically an increase in cropland. Ground truthing confirmed that the NDVI showed a rising trend in vegetation.

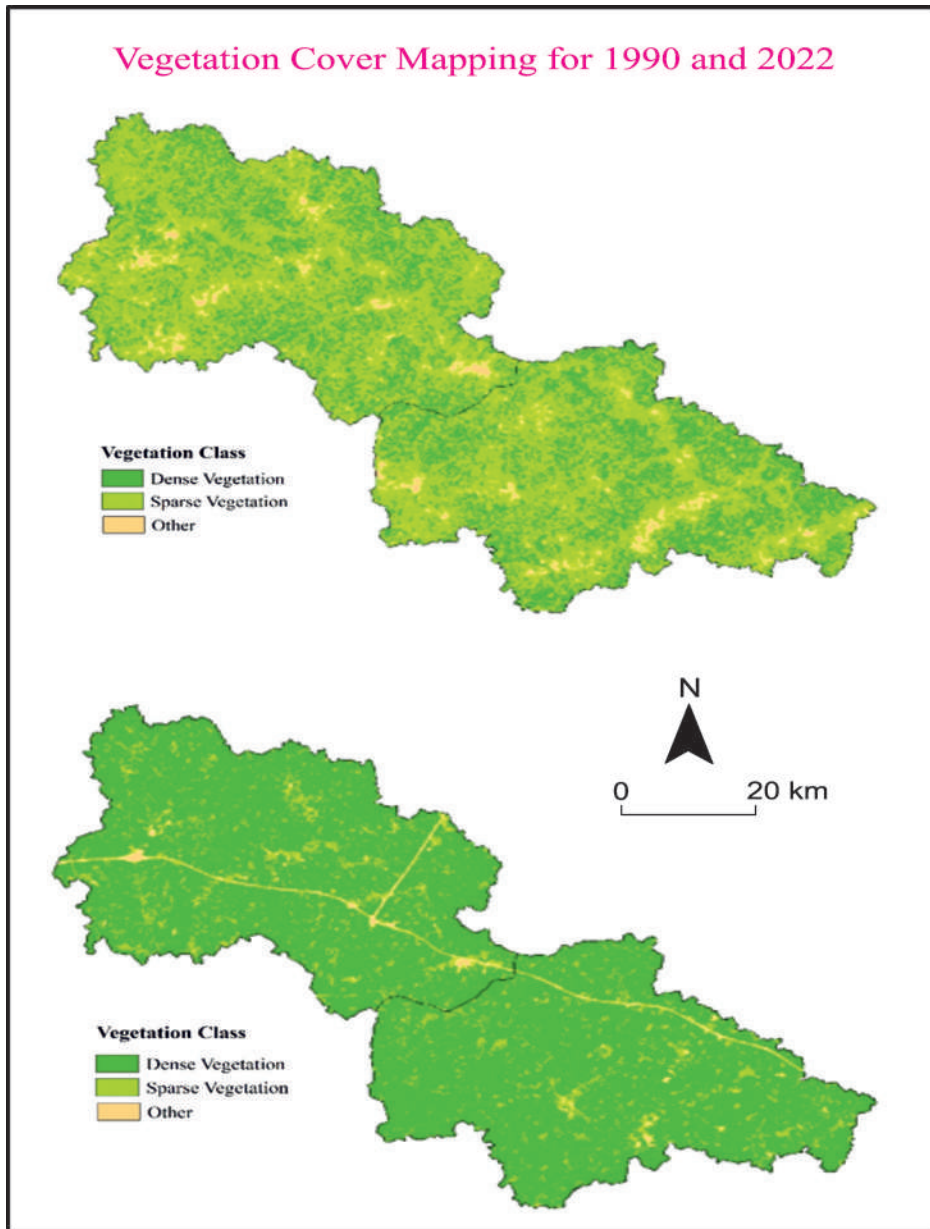


Fig. 2

This increase in vegetation, identified as cropland during field surveys. The increase in cropland and the replacement of natural vegetation are happening while the area is undergoing urbanization. As the area undergoes urbanization, it is crucial to prioritize horticultural activities in the region. This includes the conservation of valuable remnants of natural forests and the promotion of urban horticultural plantings, ensuring that the ecological balance is maintained while accommodating urban growth (Jorgensen, 1977).

Table-2: Vegetation cover Statistics in Phoolpur, 1990

Classes	Number of pixels	Area (in sq km)	Area (in percent)
Dense vegetation	70778	63.7	27.26
Sparse vegetation	172959	155.66	66.62
others	15893	14.30	6.12

Table-3: Vegetation cover Statistics on Phoolpur, 2022

Classes	Number of pixels	Area (in sq km)	Area (in percent)
Dense vegetation	223397	201.057	86.04
Sparse vegetation	30474	27.426	11.74
others	5759	5.183	2.22

## Conclusion

This study assesses the vegetation condition in the Majhuee river basin, Phoolpur tehsil, utilizing Landsat 5 and Landsat 8 datasets for the years 1990 and 2022, respectively. The NDVI maps reveal an increase in built-up areas and road network density in 2022, visible as small patches and dark green regions on the NDVI image. Notably, dense vegetation has expanded substantially from 27% of the basin area in 1990 to 86% in 2022. Field surveys confirmed that the NDVI indicated an increasing trend in vegetation, primarily due to the expansion of cropland, which has replaced natural vegetation amid urbanization. This growth is primarily driven by intensified agricultural activities, advanced agricultural technologies, and the adoption of mechanization. Agriculture around the Majhuee River basin in Phoolpur tehsil of Azamgarh has significantly increased, driven by the region's fertile soil and improved water management practices. Expanding irrigation infrastructure and adopting advanced agricultural technologies have enabled farmers to cultivate a wider variety of crops, leading to higher yields and enhanced food security. The river basin's natural resources support intensive farming activities, contributing to the

local economy and providing livelihoods for a large portion of the population. This study demonstrates the value of remote sensing and NDVI analysis in monitoring and managing vegetation cover, offering valuable insights for sustainable land use planning and environmental conservation in Phoolpur tehsil.

## References

- Bithas, K. P., & Christofakis, M. (2006). Environmentally sustainable cities. Critical review and operational conditions. *Sustainable development*, 14(3), 177-189.
- Dhinwa, P.S., Pathan, S.K., Sastry, S.V.C., Rao Mukund, Maiumder, K.I., Chotani, ML. Singh, P., I and Sinha, R.I.P.(1992). Land-use change analysis of Bharatpur district using GIN. *Journal of the Indian Society of Remote Sensing*, 20 (4):237-250.
- Fabricante I, Oesterheld M, Paruelo JM (2009) Annual and seasonal variation of NDVI explained by current and previous precipitation across Northern Patagonia. *J Arid Environ* 73:745–753
- Jorgensen, E. (1977). Vegetation needs and concerns in urban areas. *The Forestry Chronicle*, 53(5), 267-270.
- Lawley, V., Lewis, M., Clarke, K., & Ostendorf, B. (2016). Site-based and remote sensing methods for monitoring indicators of vegetation condition: An Australian review. *Ecological Indicators*, 60, 1273-1283.
- Ling, H., Guo, B., Zhang, G., Xu, H., & Deng, X. (2019). Evaluation of the ecological protective effect of the "large basin" comprehensive management system in the Tarim River basin, China. *Science of the total environment*, 650, 1696-1706.
- Liu, C., Zhang, X., Wang, T., Chen, G., Zhu, K., Wang, Q., & Wang, J. (2022). Detection of vegetation coverage changes in the Yellow River Basin from 2003 to 2020. *Ecological Indicators*, 138, 108818.
- Piao SL, Fang JY (2003) Seasonal variation of response of terrestrial vegetation to climate change in China from 1982 to 1999. *Geogr J* 58(01):119–125
- Ren, Z., Tian, Z., Wei, H., Liu, Y., & Yu, Y. (2022). Spatiotemporal evolution and driving mechanisms of vegetation in the Yellow River Basin, China during 2000–2020. *Ecological indicators*, 138, 108832.
- Schirpke, U., Timmermann, F., Tappeiner, U., & Tasser, E. (2016). Cultural ecosystem services of mountain regions: Modelling the aesthetic value. *Ecological indicators*, 69, 78-90.
- Willis, C., Papathanasopoulou, E., Russel, D., & Artioli, Y. (2018). Harmful algal blooms: the impacts on cultural ecosystem services and human well-being in a case study setting, Cornwall, UK. *Marine Policy*, 97, 232-238.
- Zahir, S. A. D. M., Omar, A. F., Jamlos, M. F., Azmi, M. A. M., & Muncan, J. (2022). A review of visible and near-infrared (Vis-NIR) spectroscopy application in plant stress detection. *Sensors and Actuators A: Physical*, 338, 113468.

--Shivam Singh  
Research Scholar  
Department of Geography  
University of Allahabad, Prayagraj  
(Uttar Pradesh)

--Ashwajeet Chaudhary  
Professor and Head  
Department of Geography  
University of Allahabad, Prayagraj  
(Uttar Pradesh)



## **GROWTH AND CHALLENGES OF TOURISM DEVELOPMENT IN VARANASI CITY, UTTAR PRADESH**

Anand Kumar Soni and Dr. Amit Kumar Chaturvedi

### **Abstract**

The holy city of Varanasi has a distinct sense of spirituality and a unique tangible and intangible heritage, attracting millions of tourists annually. Varanasi has recently become a favorite tourist destination due to its new developments, including the redevelopment of the Kashi Vishwanath Temple and improvements in facilities. These improvements have not only boosted religious, cultural, and historical tourism but also created opportunities in other forms of tourism, such as ayurveda and medical tourism, cruise tourism, educational tourism, and sports tourism. This is due to the efforts of the governments and local authorities. In 2022, there was a significant surge in tourist arrivals in Varanasi. However, tourism development faces numerous issues and challenges that can impact its sustainability and growth. This study discusses growth, new developments, and some key issues or challenges that exist in Varanasi. A mix method approach is adopted in this study, which is mainly based on secondary data and the researcher's observations during the field visit.

### **Introduction**

Tourism stimulates economic growth by creating a ripple effect and positively utilizes unique local cultural and natural features (Zimmer & Grassmann, 1996). In the contemporary landscape, tourism and development complement each other. The growth of tourism enhances the development and prosperity of a destination, just as the development of a destination fuels the growth of tourism. Sustainable tourism development aims to boost local prosperity by maximizing tourism's contribution to the destination's economic well-being, including emphasizing the retention of visitor spending within the local area (Chilembwe & Mponda, 2016). Tourism in India is often associated with spiritual and cultural experiences, with Varanasi being a prominent destination in this regard. Varanasi, recognized as Kashi or Banaras holds the distinction of being one of the most ancient cities globally and serves as India's epicenter of culture. Recently, Varanasi has gone through a big change and

become a popular place for tourists, one major reason for this is the makeover of the famous Kashi Vishwanath Temple, which shows how the city is changing and becoming more modern. Better facilities and improved buildings have been crucial in making Varanasi more welcoming to a wide range of tourists. Even though Varanasi is still known for its spiritual and cultural importance, it has expanded its tourism options to include history, medical and ayurveda, cruises, tent city stays, education, and sports. These developments can be attributed to the dedicated efforts of the government and local authorities who are committed to preserving the city's heritage while simultaneously embracing progress. Sustainable tourism development is about making sure that we can keep enjoying beautiful places and that local people can have good lives for a very long time. Understanding the problems and difficulties is crucial because it helps us grasp why sustainable tourism development is so vital. The purpose of this study is to explore the city's tourism growth and newfound developments, shedding light on the key issues and challenges that confront its sustainability and continued expansion.

### **Study Region**

Varanasi District is located in the Gangetic Plain in the eastern region of Uttar Pradesh. It is bordered by Jaunpur to the north, Ghazipur to the northeast, Chandauli to the east, and Sant Ravidas Nagar to the west. Varanasi city serves as the administrative headquarters of the district, extending along the curving left bank of the Ganges River. It is positioned between the latitudes  $82^{\circ} 56'E$  -  $83^{\circ} 03'E$  and longitudes  $25^{\circ} 14'N$  -  $25^{\circ} 23.5'N$ , confluence of the Ganges with two other rivers: the Varuna and the Assi stream. The city is included in the 'Varanasi Urban Agglomeration' (VUA). As a result of the escalating population growth and swift progress of Varanasi, it achieved the status of a million city by 1991 (Jha & Tripathi, 2015). Varanasi ranks as the fifth most densely populated city in the region. It holds a Class II city classification and had a municipal area population of 1,201,815 according to the 2011 Census. Furthermore, the overall population encompassed within its Urban Agglomeration amounts to 1,435,113. The sacred city of Varanasi is home to a diverse array of religious sites, with approximately 3300 Hindu temples, 1388 Muslim shrines, 45 Sikh locations, 11 Buddhist places, 4 Jain temples, and numerous markers honoring various folk deities. These collectively contribute to the rich tapestry of sacred spaces in the city (cf. Singh 2009a).

### **Objectives**

- (1) To explore the recent changes in tourist arrivals in the study area.

- (2) To investigate recent developments and governmental efforts to enhance tourism.
- (3) To examine key issues and challenges that exist in the study area.

### **Database and Methodology**

The research employed a mix method approach, predominantly relying on secondary data sources such as government reports, newspapers, books, various research papers, articles and websites. The recommendations presented in the paper are informed by the author's firsthand experiences and observations gathered through visits to the city and interviews with locals and tourists. These observations are unadorned and stem from the researcher's regular visits during fieldwork.

### **An Overview of Tourism in Varanasi**

#### **Ghats and Temples**

Ghats are basically a series of steps lining the river's edge. The western bank of the Ganga River features 84 Ghats arranged in a crescent shape, spanning a distance of 6.8 kilometers in Varanasi. Most important Ghats are Dashashwamedh Ghat, Manikarnika Ghat, Assi Ghat, Harishchandra Ghat, Panchganga Ghat, Rajendra Prasad Ghat, and Adi Keshav Ghat etc. Varanasi is known as city of temples. Kashi Vishwanath Temple, Durga Temple, Sankat Mochan, Tulsi Manas Temple, New Vishwanath Temple, Annapurna Temple, Bharat Mata Temple, The Nepalese Temple, Lolark Kund Temple & Varahi Devi Temple etc are some famous temples in Varanasi (**Fig. 1**).

#### **Maths, Ashrams and Fort**

Varanasi is the center of Indian philosophy, mysticism, spiritual practices, Vedic heritage, and numerous religious organizations, each with their own maths and ashrams. Kabir Math (Lahartara), Satua Baba Ashram, Kinaram Math, Sri Sringeri Shankar Math, Ramakrishna Mission Sevashrama, Mata Anandamayi Ashram, International Music Centre Ashram, Santmat Anuyayi Ashram etc are some important maths and ashrams in Varanasi. Ramnagar fort is situated approximately 14 kilometers from Varanasi, the fort stands resplendent in red sandstone on the opposite side of the sacred Ganges River, which flows alongside the thriving city of Varanasi. The fort's architecture beautifully melds Islamic and Indian styles, and it was constructed by Maharaja Balwant Singh in the 18th century. The annual Dussehra celebration at Ramnagar Fort is renowned throughout India for its grand and lavish festivities.

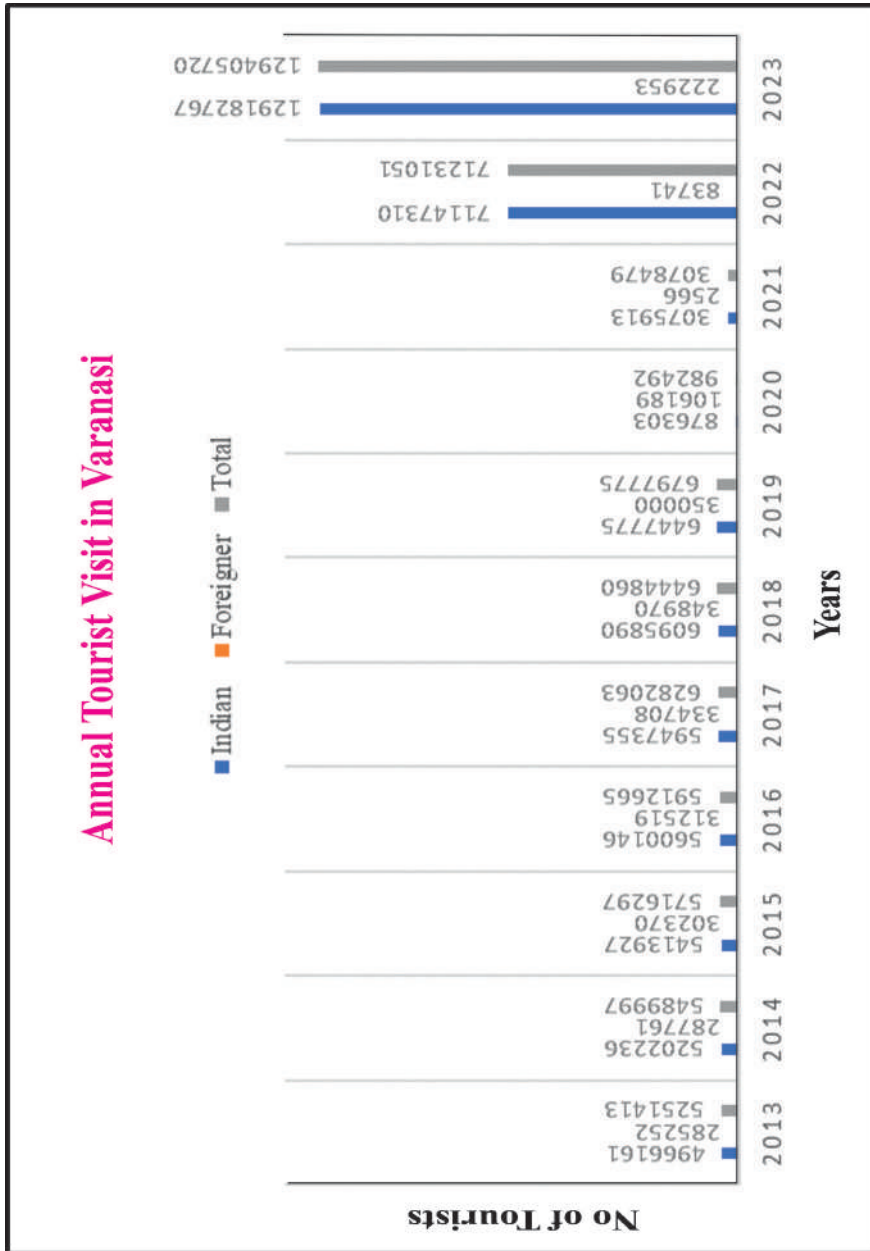


Fig. 1

### **Buddhist and Jain Pilgrimage**

Sarnath holds a significant place in Indian Buddhism as one of the foremost pilgrimage sites. It's where Lord Buddha delivered his inaugural sermon, and it's celebrated for its historical relics of Buddhist stupas, monasteries, and temples. This sacred site is located approximately 10 kilometers north of the city of Varanasi. Key attractions in Sarnath include the Chaukhandi Stupa, Dhamekh Stupa, Dharmrajika Stupa, Mulagandhkuti Vihara, as well as the Chinese Temple, Burmese Temple, Jain Temple, and Sarnath Museum. In accordance with Jain customs, Varanasi holds the distinction of being the birthplace of four revered Tirthankars: Bhagwan Suparshavnath ji, Chandraprabh ji, Shrensnath ji, and Parshvnath ji. The 7th Tirthankar, Suparshvnath ji, was born in Bhadaini near the banks of the River Ganga. The 11th Tirthankar, Shreyanshnathji, was born in Singhpur, which is located 1 km from Sarnath and is famously known as the Digambar Jain Temple. The 23rd Tirthankar, Shri Parshvnath, was born in Bhelupur.

### **BHU Campus**

Pandit Madan Mohan Malviya established Banaras Hindu University in 1916. The university boasts a vast 1300-acre campus renowned for its stunning beauty, including the presence of the Shri Vishwanath Temple within its grounds.

### **Fair and Festivals and Art and Culture**

As a hub of spirituality, Varanasi is vibrant with various festivals and fairs happening year-round such as Bharat Milap, Buddha Purnima, Dev Deepavali, Ram Leela of Ramnagar, Nag Nathaiya, Nakkataya, Shivratri, Ganaga festival, Sankat Mochan Music Festival etc. Varanasi, often referred to as the City of Music, Drama, and Entertainment, is celebrated for its rich traditions in vocal and instrumental music, indigenous dance forms, and vibrant cultural scene. This includes an abundance of folk music and theatrical performances, with notable events such as Ramlila, musical gatherings, fairs, and festivals.

### **Handicrafts**

Varanasi has been historically recognized as a prominent hub for Indian handicrafts for centuries. Banarasi saris are renowned as some of the most exquisite in India, prized for their intricate gold and silver brocade (zari), luxurious silk, and elaborate embroidery. In Varanasi, the craft of Meenakari, also known as enameling, was thriving until approximately a century ago. Banarasi Kundankari is an age-old craft of crafting ornaments, and only a handful of artisans are striving to safeguard and uphold this tradition.

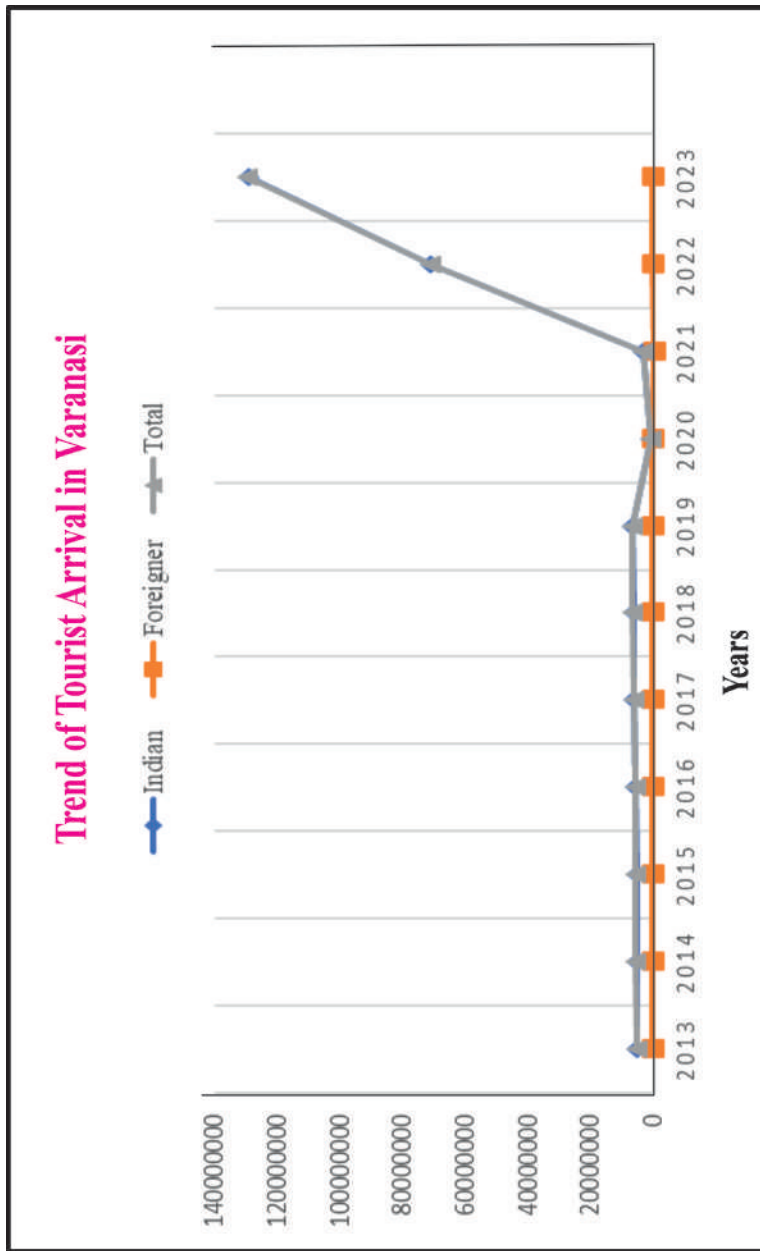


Fig. 2

### Yoga & Medical Tourism

Due to the presence of accessible Ayurvedic practitioners and reasonable rates, Varanasi stands out as a leading choice for individuals seeking Ayurveda and medical tourism. Varanasi enjoys global recognition for its numerous Yoga and Meditation Ashrams. There are many ancient spiritual ashrams situated along the sacred Ganges River. These ashrams offer a variety of Yoga and Meditation Retreats, Programs, and Initiation Courses. There are numerous government and private hospitals in Varanasi, including trauma centers, making it a destination for many individuals who travel primarily to seek medical treatment (Table-1 and Fig. 2).

### Growth and Performance of Tourism

Table-1: Annual Tourist Visit in Varanasi

Year	Indian	Foreigner	Total
2013	4966161	285252	5251413
2014	5202236	287761	5489997
2015	5413927	302370	5716297
2016	5600146	312519	5912665
2017	5947355	334708	6282063
2018	6095890	348970	6444860
2019	6447775	350000	6797775
2020	876303	106189	982492
2021	3075913	2566	3078479
2022	71147310	83741	71231051
2023	129182767	222953	129405720

Source: [uptourism.gov.in/en/post/Year-wise-Tourist-Statistics](https://uptourism.gov.in/en/post/Year-wise-Tourist-Statistics)

The data reveals Varanasi's tourist numbers over the past decade, showing steady growth from 2013 to 2019, staying below 7 million. However, tourism sharply declined in 2020 due to the COVID-19 pandemic and subsequent lockdowns. 2021 showed signs of recovery, and in 2022, Varanasi experienced a dramatic increase to approximately 70 million visitors. This surge was primarily driven by a substantial rise in Indian tourists, attributed mainly to the redevelopment of the Kashi Vishwanath corridor. In 2023, the number of visitors to Varanasi peaked, surpassing 120 million.

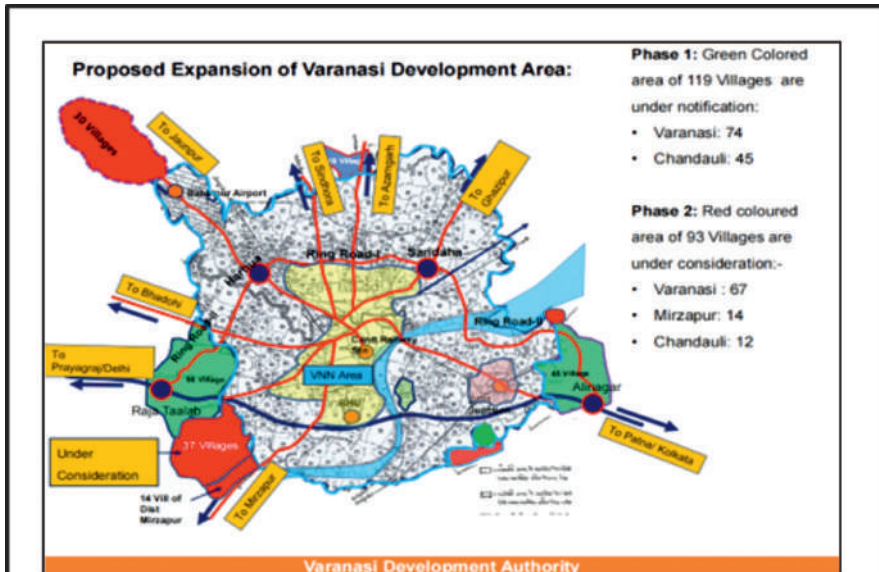


Photo:1 - Proposed Extension of Varansi Development Area

Source: Development Vision of Varanasi 23/09/2022



Photo:2 - Demolition Work During Development of Kashi Vishwanath Corridor

Source: The Hindu

### **Government Efforts, New Developments and Future**

The Varanasi Master Plan for 2031 identifies six specific zones within the city that hold significance in terms of archaeology, history, religion, and cultural heritage. These zones are, namely, (1) Ganga Ghats & Temple area (2) Durga Temple, Sankat Mochan & Manas temple area (3) Kamachcha- Bhelupur area (4) Kabir Math (Lahartara) area (5) Sarnath area (6) Area of Panchkoshi Yatra. The Varanasi Development Authority is overseeing several projects aimed at redeveloping and restoring heritage areas, along with innovative development initiatives such as creating a Tent City on the banks of the Ganges in Varanasi and establishing a Ropeway System. These endeavors are expected to provide a new dimension to tourism in Varanasi. The Master Plan for 2031 focuses on the expansion of the Varanasi Development Area, which will also encompass certain villages from adjacent districts. The government is also emphasizing sports and cruise tourism. Multiple development projects are underway, including developing the Dr. Sampurnanand Sports Stadium, constructing an indoor stadium within it, establishing an international cricket stadium in the Raja Talab area, and operating cruises on the River Ganga. G20 summit 2023 was held in the Indian presidency and Varanasi also hosted many events of G20. These events were set as a platform to showcase India's profound cultural legacy and provide G20 delegates and other attendees with distinctive and captivating experiences. These events played a crucial role in speeding up various initiatives aimed at improving the city's facilities and services to reach a globally competitive standard (**Photo-1 and 2**).

### **Challenges**

Varanasi, one of India's ancient cities, is experiencing rapid population growth, boasting a population of approximately 1.5 million individuals, and it is also witnessing a significant increase in the number of visitors. Currently, the city's available land area spans 82.10 square kilometers, proving insufficient to cater to the expanding population, tourists, and their requirements. The population density in the ancient Ganga river and its adjoining parts of the city is 1000 to 1500/person per hectare. Traffic congestion is a pressing issue in Varanasi. The city's streets are narrow and frequently congested. The challenge is exacerbated by the absence of adequate parking facilities, public transportation, and effective traffic management. The relocation of current shops, vendors, and residences are a big challenge as well. A shortage of housing for residents is a problem in Varanasi. Excessive crowding gives rise to "overtourism," which is detrimental to the objective of achieving sustainable tourism development. United Nations World Tourism Organization

UNWTO (2018) defined overtourism is a situation observing a severe impact made by tourism on a destination or its parts, which badly influences the quality of life of its residents. Effectively addressing the issue of overtourism in Varanasi poses a significant challenge.

### **Environmental Degradation**

Environmental deterioration is a serious concern that gives rise to numerous health hazards, biodiversity threats, climate-related issues, and economic challenges. Numerous research findings indicate that Varanasi is confronted with a host of environmental issues, including problems related to air quality, water quality, and the management of solid waste etc. The rise in tourism, increased use of personal vehicles, air travel, and greater car ownership have led to higher levels of air and noise pollution in Varanasi. This pollution has resulted in a range of issues, including health problems, emissions, acid rain, increased CO<sub>2</sub> levels, environmental disturbances, and harm to plant life. Notably, noise pollution is a significant issue in Varanasi, especially due to heavy traffic and the use of vehicles like jeeps and buses in areas with inadequate road infrastructure, where many tourist attractions are situated. The critical issues in Varanasi include the disposal of sewage, the practice of immersing deceased bodies for religious reasons, the release of industrial effluents, the discharge of chemicals and dyes from cottage industries like Banarasi sarees, the use of soap, oil, and datun (tooth-cleaning twig) by pilgrims, open defecation, and the dumping of flowers and waste from hundreds of temples into the Ganges. Microplastic pollution is increasing in the Ganga River in Varanasi, with Assi Ghat displaying the highest microplastic levels, possibly due to its popularity and connection to the city via a wide street (Mahesh et al., 2021). According to Varanasi Master Plan Draft, in the city, 225 MLD of sewage is generated, out of which only 97 MLD is treated in sewage treatment plants (STPs), and the remaining 130 MLD is discharged into the Ganga and Varuna rivers through open drains. Pollution damages ecosystems, while alterations in infrastructure exacerbate soil degradation. The living conditions in heritage areas have significantly deteriorated in terms of quality. These concerns collectively pose significant environmental challenges in the city.

### **Heritage Preservation with Development**

Varanasi is renowned for its heritage architectural significance such as centuries-old buildings, ancient temples, ghats, and other old architectures. Numerous heritage sites are situated in close proximity to each other in Varanasi.

Heritages are vulnerable to the risk of destruction. The influx of tourists places additional stress on the city's heritage sites. In the view of rapid growth of tourism, several development initiatives are currently underway to improve visitor amenities and transform Varanasi into a smart city. It is a very challenging task to balance development with heritage preservation.

### **Management of Resources**

The management of resources in Varanasi presents a significant challenge, exacerbated by overcrowding and overtourism. This includes both natural and man-made resources such as land, groundwater, drinking water, and infrastructure like hotels and transportation. For instance, the rapid expansion of urban areas like Ramna has led to unplanned construction, resulting in the swift conversion of agricultural land into residential areas. Similarly, there were a total of hundred Kunds in Varanasi, of which currently only 88 are left and the remaining have dried up due to climate change and encroachment (Varanasi master plan draft).

### **Cultural Sensitivity**

Cultural sensitivity refers to the awareness, respect, and consideration for the cultural beliefs, customs, values, and practices of individuals or groups from different cultural backgrounds. Excessive tourism can exacerbate concerns regarding cultural sensitivity, such as some tourists might capture photos and videos of cremation ceremonies at the ghats without obtaining proper permission or showing respect for those in mourning. The impact of modernization and globalization poses a threat to the sustainability of cultural uniqueness.

### **Safety and Security**

While Varanasi is renowned as a pilgrimage destination, it faces a notable deficiency in ensuring the safety and security of tourists and their belongings. The absence of a dedicated tourist police force in the region contributes to a negative perception among both current and potential visitors (Chatterji, 2022).

### **Sanitation and Health**

Sanitation management issues are prevalent in Varanasi's heritage zones, particularly around the Ghats where various religious ceremonies take place. Varanasi already struggles with managing household waste, and this additional challenge has led to open dumping in the heritage areas and into the River Ganges, further polluting these historically significant zones. It has an open drain system

in the main city region, which overflows during rain. Poor sanitation contributes to elevated health risks. The surge in tourism amplifies the demand for healthcare facilities to address the medical requirements of tourists.

### **Slums & Beggar**

Two of the most conspicuous and visible concerns in Varanasi are the presence of slums and beggars. In 2015, there were 210 slums in the city, with a total population of 407,036 residing in 78,253 households within these slum areas, according to data from the Ministry of Urban Development. Among the 210 slums, 156 are situated in the central core areas, which include places like central business districts, areas around temples, and small-scale industrial zones. The remaining 54 slums are found in the urban fringe areas near agricultural lands (Bhardwaj & Pandey, 2021). Varanasi often witnesses beggars, particularly in the vicinity of the ghats where pilgrims and tourists gather to partake in rituals and ceremonies. This leaves a negative impact on the tourism experience. The presence of slums and beggars presents a hurdle for the growth and reputation of Varanasi, a city that aims to transform into a smart city and a global tourism hub.

### **Inadequate Roadside Facilities**

The subpar infrastructure and services in Varanasi, including inadequate road maintenance, railway stations, bus terminals, low-quality roads, substandard guesthouses, drinking water issues, insufficient information and communication facilities, and challenges with local auto drivers and rickshaw operators, hinder the region's ability to sustainably develop pilgrimage tourism (Chatterji, 2022). The government is indeed taking steps to address this problem, including the introduction of new bus terminals, the construction of overpasses, and other measures. However, these efforts are still insufficient to meet the demands of increased tourism.

### **Insufficient Collaboration among Parties Involved**

There is a noticeable deficiency in cooperation and mutual understanding among the diverse stakeholders engaged in tourism activities in Varanasi. The Municipal Corporation, VDA, and others, each maintain their separate inventories of heritage structures and monuments, without ever consolidating them into a comprehensive, unified list. This lack of coordination indicates a significant absence of connectivity between various institutions and their technical expertise in matters concerning heritage preservation and management, which is critically required at this time.

### **Lack of Participation of Local Communities**

Effective heritage conservation and management rely heavily on the extent of public awareness and the degree of reverence people hold for their heritage assets and culture. In the case of Varanasi, there is a notable insufficiency in both these areas. Hence, the accomplishment of sustainable development objectives in this context is unattainable without the active involvement and participation of local communities.

### **Conclusions and Recommendations**

Varanasi is experiencing a resurgence in tourism after a decline due to COVID-19, and it's great that there's progress with development projects. However, it's crucial to balance this growth with sustainable tourism practices to avoid overtourism. Overtourism can strain local resources, impact the environment, and affect the authenticity of the destination. To address this, it might be beneficial to focus on strategies, namely, (1) Regulating Visitor Numbers could involve ticketing systems for popular attractions or even congestion pricing during peak hours (2) Partner with hotels and guesthouses to provide information about responsible behavior to visitors upon check-in. Collaborate with tour operators to create itineraries that highlight lesser-known cultural experiences. Heritage walks, traditional craft workshops, and visits to local villages to showcase the rich tapestry of Varanasi's life beyond the ghats. Develop walking and cycling tours to encourage sustainable Invest in waste management solutions to handle the increased waste generated by tourists. Improve public transportation to reduce reliance on private vehicles and traffic congestion. Support training programs for local residents to become involved in the tourism industry as guides, homestay providers, or artisans selling crafts. Establish a community development fund where a portion of tourism revenue is directed towards local infrastructure projects or social initiatives. By implementing these strategies, Varanasi can ensure that tourism continues to be a force for positive economic development while preserving the city's unique character for future generations.

### **References**

- Chatterjee, K., (2022), Modern Tourism Development through Sustainable Tourism Approach: A Case study of Pilgrimage Tourism in Varanasi (Vol. 10). [www.ijcrt.org](http://www.ijcrt.org)
- Praharaj, Sarbeswar. (2014). Conservation and Urban Renewal as a base for Sustainable Development in Historic Cities: A Case of Varanasi.
- Bhutia, S. (2014). Growth & Development of Tourism Sector in West Bengal: Issues & Concerns.

- Singh, R. P. B. (2017). Varanasi, the Heritage Capital of India: Valuing the Sacredscapes; <https://banaras.academia.edu/RanaPBSINGH/>
- Jha, Darshan/Tripathi, V. (2015). Quality of Life in Slums of Varanasi City: A Comparative Study. [S.I.]: SSRN. <https://ssrn.com/abstract=2597839>.
- Singh, Rana P.B. 2009a. Banaras, the Heritage City of India: Geography, History, and Bibliography. Also, historical chart, a list of 1100 shrines and divinities and their locations, and Hindu Festivals, 2006-15. Pilgrimage and Cosmology Series: 8. 456 pp.; 13 statistical tables, 32 figures; 1276 entries. Indica Books, Varanasi.
- Malani, Preeti & gupta, Sachin & Chaturvedi, Ankita. (2020). Digital Trends: A Problem or a Solution for Overtourism. SSRN Electronic Journal. 10.2139/ssrn.3668778.
- Malik, Tanay. (2012). Management of Tourism Industry in Varanasi (Ph.D. Thesis, Mahatma Gandhi Kashi Vidyapeeth, Varanasi)
- Tiwary, Akhileendra Nath. (2016). Prospects and Constraints in Development of Varanasi as Smart City, India. International Journal of Advanced Scientific Research and Management, Vol. 1 Issue 3, March 2016. 11. 71-80.
- Mahesh, Priti & Saha, Mahua & Chauhan, Amit. (2021). Microplastics Quantitative Analysis of along River Ganga For full report <http://toxicslink.org/docs/Quantitative%20analysis%20of%20Microplastics%20along%20River%20Ganga.pdf>.
- Bhardwaj, A., & Pandey, A. K. (2021). Socio-Economic Status of Slum Dwellers: A Cross-Sectional Study of five slums in Varanasi City. Journal of Global Economy, 17(3).
- P. Zimmer and S. Grassmann, "Evaluating A Territories Touristic Potential", LEADER seminar in Sierra de Gata, 1996 [web:<http://ec.europa.eu/agriculture/rur/leader2/rural-en/biblio/tourism/metho.pdf>]
- Chilembwe, J.M. & Mponda I.K. (2016). Tourism Sustainable Governance Practices in Malawi as Tourist Destination: The Challenges and Opportunities for Tourism Development. Tourism Spectrum, Vol. 2, No. 1, March 2016, pp. 1-10
- Varanasi Master Plan Final Draft 2031, published by Varanasi Development Authority; [https://vdavns.com/varanasi\\_master\\_plan\\_2031](https://vdavns.com/varanasi_master_plan_2031)
- Development Vision of Varanasi 23/09/2022, published by Varanasi Development Authority, Uttar Pradesh Government
- City Audit Assessment Study–Understanding Varanasi City from the Lens of Disability Inclusion–October 2021, published by National Institute of Urban Affairs
- UNWTO. (2018). Overtourism? Understanding and Managing Urban Tourism Growth beyond Perceptions: Executive Summary.

--Anand Kumar Soni  
Research Scholar  
B.R.D.B.D.P.G. College, Ashram Barhaj  
Deoria (Uttar Pradesh)

--Dr. Amit Kumar Chaturvedi  
Assistant Professor  
B.R.D.B.D.P.G. College, Ashram Barhaj  
Deoria (Uttar Pradesh)



## **IMPACTS OF FLOODS IN CHEYYERU RIVER- A STUDY OF RAJAMPETA REVENUE DIVISION IN YSR KADAPA DISTRICT, ANDHRA PRADESH**

N. Sreedhara Naidu

### **Abstract**

Floods have been one of the most devastating natural climatic occurrences since the dawn of time. It is most commonly observed during the monsoon season that severe floods occur every year in one part of the country. Flooding is primarily caused by River bank overflow, and its severity increases where there are obstructions such as roads, building railway networks, and urban areas (Khama et al 2007). Flood waters are simply going as waste into the seas and oceans and by controlling the flood. The present study was conducted in the Cheyyeru River area of the Rajampeta Revenue Division of the YSR Kadapa District of Andhra Pradesh. The Cheyyeru River is one of the tributaries of the Penna River in YSR Kadapa District. The objectives of the study are (i) to investigate the rainfall temperature and humidity patterns in the study area; and (ii) to study and analyze the causes and factors leading to the flood in the study area. (iii) to analyze the flood vulnerability and risk mitigation measures in the study area. The present paper analyzes the rainfall pattern, causes and factors, impacts and vulnerability, risk reduction strategies, damages, flood-affected population, flood assistance activities, etc. of the study area.

### **Introduction**

Floods have been one of the most devastating natural climatic occurrences since the dawn of time. It is most commonly observed during the monsoon season. Severe floods occur every year in one part of the country. Floods cause tremendous and extensive damage to agriculture, life, and property, besides causing huge suffering. Due to different domestic rainfall patterns in seminal regions, they experienced severe inundation. Thus, floods are the single biggest disaster facing the country. Flooding is primarily caused by river bank overflow and its severity increases where there are obstructions, such as roads, railway networks, and urban areas (Khama et al. 2007). Flood waters are simply going as waste into the seas and oceans,

and by controlling the floods, we can utilize the waters for irrigation and other purposes. The infrastructure development of rivers can be a substantial and suitable solution. For the progress and development of our areas, there is a need to study the floods extensively and implement flood mitigation measures to safeguard the crops and agricultural crops from frequent flood devastation in major cities and towns of our country. We need to understand the causes of the most common disaster events, such as floods, which are extremely difficult to manage in densely populated urban and rural areas and directly or indirectly disrupt the livelihoods of millions of people. Therefore, there is a need to examine the factors that contributed to the floods and need to be studied. The findings would help address sustainable urban and rural development. This study attempts to assess the flooding problems in the Penna River YSR Kadapa district of Andhra Pradesh State. This project emphasizes more flooding problems in the study area. This area (YSR Kadapa) was selected as it represents an area of recent devastation in terms of the incidence of floods. This project would carefully examine and assess the flooding problems on the Penna River banks of the YSR Kadapa district.

### **Study Region**

The Rajampeta Revenue Division is one of the revenue divisions of YSR Kadapa District of Andhra Pradesh State. It is located in Rajampet mandal of Rajampeta revenue division. It is bordered by Tirupati to the south, Nellore to the east, Sri Sathya Sai to the west, and YSR district which consists of 9 mandals under its administration divisions Railway Koduru, Chitwel, Nanandalur, Obuluvaripalle, Penagalur, Pullampeta, and Rajampeta, Veeraballi and T sundupalle, The dry Cheyyeru River bed that runs between Rajampet-Rayachoti and Balarasapalli village is located between latitude 14012N and longitude 79001E. The town has an average elevation of 139 meters (456 ft) (**Fig. 1**). It receives an average rainfall of 50–70 cm per annum, Major Rivers in Penna and Cheyyeru and its Tributaries Pincha, Bhahuda, Mandavya River in study area.

### **Objectives**

- (1) To investigate the rainfall temperature and humidity patterns in the study area.
- (2) To study and analyze the causes and factors leading to the flood in the study area.
- (3) To analyze the flood vulnerability and risk mitigation measures in the study area.

## Database and Methodology

Flood management and risk reduction are visions and ways of thinking and acting in relation to human inhabitants and the natural environment that have the potential to resource and environment in the future. The present study is carried out through the evaluative method of research, which helps in gaining an understanding of the specific events of food to provide an exploitable rendering of the structure order and broad pattern for a better understanding through empirical experience and truthful reporting.

## Rivers in Study Region

The Cheyyeru river is formed by the confluence of the Rivers Bahuda and Pincha that originate in the district of Andhra Pradesh. The two streams join at Rayavaram to form the Cheyyeru which then flows for 87 km before joining the Pennar as a right bank tributary at Gundlamada in the Sidhout taluk of Kadapa District, draining a total area of 7,325 km<sup>2</sup>. The Gunjana River is a tributary of the Cheyyeru and along the Gunjana valley several paleolithic settlements have been discovered. There are several gorges on the river including one after the confluence of its headstreams and the Balarajupalle gorge (Table-1). The Cheyyeru series of rocks in the Cudappah rock system of the Eastern Ghats, consisting largely of shales, is named after the Cheyyeru River (**Fig. 1**).

Table-1: Salient Features of Irrigation Flood Affected Areas Reservoirs in YSR Kadapa District

Name of the Dam	Pincha Dam	Annamayya Project
Project Identification Code	AP01MH0016	AP01MH0129
Longitude, Latitude	NOT GIVEN	79 0 01' 15" E; 14 0 12' 06" N
Nearest Town	Rayachoti	Rajampeta
Earthen Dam height above lowest Foundation	21 m	25 m
Length of Dam	486 m	409 m
Gross Storage Capacity	9.284 MCM	63.5 MCM
Effective Storage Capacity	9.1 MCM	44.89 MCM
Reservoir Area	207.3 ha	760 ha
Spillway Capacity	1644 cumecs	8069 cumecs

Annamayya Project is a medium irrigation project with a gross capacity of only 2.24 TMC ft constructed across the Cheyyeru River a tributary to Pennar. The Cheyyeru project comprising the 409 meter long Annamayya earthen dam that provides irrigation facilities to its catchment zone is on this River. It is located near Badanagadda village under Rajampet Mandal in Rajampeta constituency of the YSR Kadapa District. The dam irrigates 10,000 acres of agricultural land. In addition, the dam meets the drinking water needs of Raja pet and the surrounding villages. It caters to an ayacut of 22,500 acres, besides fulfilling the drinking water needs of 140 habitations. The people of Rayalaseema in Andhra Pradesh have been severely affected by the storm in the Bay of Bengal. As many as 30 people have been killed so far in floods. According to official information, 8 people were reported swept away in the floods. But locals say the number could be even higher. The flash floods in Andhra Pradesh have caused severe damage in districts including YSR Kadapa, Chittoor, Anantapur and Nellore recently. If action had been taken in time, we could have minimized the damage. The death toll has risen due to a lack of precautionary measures. (Said, Tariq al-Hashimi, the party's secretary general).

### **The Ancient Annamayya Dam was broken**

They regulate the flow of water by increasing the amount of water discharged from the reservoir. However, due to the floods, the reservoir reached a discharge level of 5.38 lakh cubic feet. He flash flood caused due to a breach of the project's earthen bund caught at least 18 people in a watery grave and left many others missing in these villages. After the Pulichintala dam gate disaster in August 05, 2021, the state of Andhra Pradesh witnessed another dam-induced flood disaster in 2021. This started with, part of the Annamayya dam in Penna (also called Penna) River basin getting washed away resulting in widespread destruction in downstream areas on November 19, 2021.

### **Pincha and Annamayya Dam Failures**

Through Pincha, Mandavya and Bahuda Rivers feeding Cheyyeru River .The Annamayya project had received around 1.80 lakh cusec inflows by November 18 night. Amid heavy downpour, the ring bund of upstream Pincha dam project got damaged in the hours of November 18 flushing additional inflows of around 1.40 lakh cusec in Annamayya dam. Cumulatively, the project received about 3.20 lakh cusec inflows against the total discharge capacity of 2.85 lakh cusec in the early morning hours of November 19, 2021. As a result, part of the left portion of the dam's earthen bund collapsed around 06:00 am on November 19, 2021 causing a flood

disaster in dozens of downstream villages. It is also reported that one of 5 spillways of the dam got jammed during peak flood causing massive damages to the project.

### **Reasons for Break Down at Annamayya Dam Failure**

This is due to (i) Annamayya dam management and administrative issues related to the dam. (ii) Dam was initially planned to hold only 2 lakh cubic feet of water, but how the flood waters are overflowing more than twice its Capacity. (iii) Cheyyeru River catchment was facing very heavy rainfall. (iv) The project receives about 3.20 lakhs cusec inflows against the total discharge capacity of 2.85. lakh cusec in the early morning hours of November 19, 2021.(v) Increase in Extreme weather events however the destruction on the ground is largely due to anthropogenic reasons and unscientific operations mismanagement of dams and projects.(vi) Dam is not large enough to hold the 3.5 lakh cubic feet of flood waters that overflowed from the Pincha dam.(vii) The River Basin areas have their large share of blame apart from encroachments of the drainage system and water bodies.(viii) One of the gates of the reservoir failed to open during the floods as a result of which the earthen bund got breached and floods gushed into the adjacent villages.(ix)The Pincha project upstream breached, letting out all floodwater into Annamayya while water from Seshachalam too came gushing in because of very heavy rainfall, resulting in an overall discharge of over two lakh cusecs. That pushed the Cheyyeru River into space, inundating at least 10 villages downstream in Rajampet and Nandaluru mandals, and leaving widespread destruction in its wake. (x) Due to the heavy rain, the dam broke and was swept away by the floods. Both the flood waters from the Pincha Dam and the flood waters from the Bahuda have caused the Cheyyeru River to flood. Thus, the Annamayya Dam is in danger.

### **Reasons behind Flood Disaster**

There are many reasons< namely, (i) Unprecedented rains are reasons behind Flood Destruction. (ii) Annamayya Project has not received this volume of water in the past 50 years. (iii) The River course changed but the dam breach was what caused the real destruction. (iv) Heavy rains (8cm to 10 cm rainfall in three hours) along the Cheyyar River and the continuous rains for a few days from November 18 were the major reasons for the floods. (v) Due to Pincha & Annamayya project breach heavy rain caused all the tributaries of Penna to flow abnormally. Inflow & outflow of Penna basin projects. As per the Collector, the dam breach was the major factor that caused such a major calamity. “The River course changed but the dam breach was what caused the real destruction. (vi) Firstly, the collapse of the Pincha



Photo 1: Annamayya Irrigation Project and Cheyyeru River

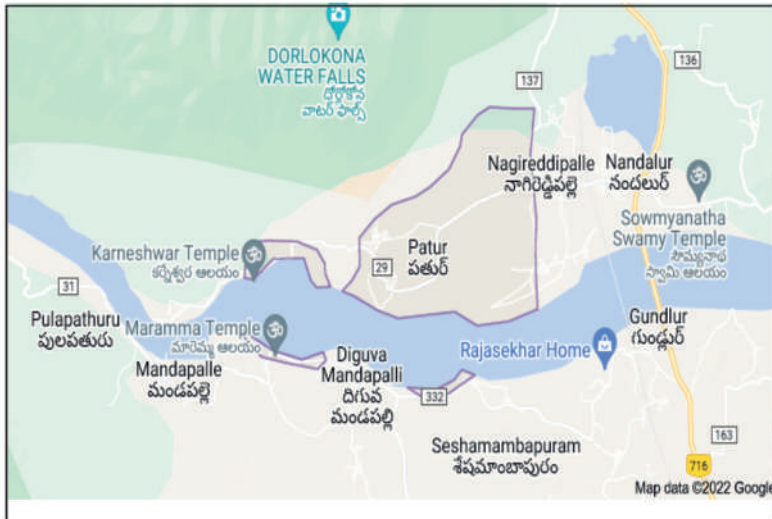


Photo 2: Google Map Image of Annamayya Irrigation Project and Cheyyeru River

project ring bund contributed to the Annamayya flood disaster. Project was washed away. (vii) Thus, the villages at the bottom of the dam were flooded. Being warned about this in advance was able to reduce casualties. Nine villages in Nandalur and Rajampet mandals were completely submerged, "he told the BBC.

### **Flood Affected Population**

Most of the Mandals are highly affected due to floods or water logging in the district. Mandal wise highest affected population is Nandalur with 10100 persons followed by 3359 persons in Penagalur and 3172 persons in Rajampeta Mandal, where as the lowest affected mandals are namely Veeraballe with only 35 persons, in T sundupalle 180 persons, in Kodur mandals 543 persons in Rajampeta Revenue Division Of YSR Kadapa District. The detail of information is given in the following **Table-2**.

### **Flood Affected Population**

Table-2: Flood Affected Population in Rajampeta Revenue Division

Sr. No.	Name of the Mandal	Total Population	Affected Population	% of Population
1.	Chitvel	42104	1,607	3.81
2	Kodur	90814	543	0.59
3	Nandalur	39902	10,100	25.31
4	Obulavaripalle	53275	2,328	4.37
5	Penagalur	42360	3,359	7.92
6	Pulampeta	39434	753	1.91
7	Rajampet	103871	3,172	3.05
8	T Sundupalle	57140	180	0.31
9	Veeraballe	35530	35	0.09
Total		504430	22077	47.36

Source: District Disaster Management Plan of Kadapa District and District Censes

### **Hand Book of Kadapa District -2011**

### **Flood Destruction**

The failure of the Pincha and Annamayya projects has caused significant damages in dozens of downstream villages including Togurupeta, Mandapalle,



Photo 3: Flood Affected Areas Cheyyeru River Adjoining Villages of Rajampeta and Nandalur Mandals YSR District



Photo 4: Tracks Washed Away in Guntakal – Tirupati flood – Many trains diverted Or Cancelled

Pulapathur, and Gundlur. The disaster has also damaged several homes and destroyed agricultural crops on hundreds of acres of land. Far 44 people have reportedly been killed and about 15 remained missing. Most of the casualties have taken place in the Rajampeta revenue division of Kadapa district particularly due to a breach in the Annamayya project. The toll consisted mostly of people who went to Shiva temples for shelter or worship during the Karthika Pournami. Mandapalli and Togurupeta villagers have blamed the administration for no timely warning and evacuation. Even the rescue and relief work was done by volunteers and police personnel in the initial hours. Annamaya dam Cheyuru sub-basin received an inflow a sudden gush of about 2 lakh cusecs of floodwater, with the level reaching up to 10 feet height, caught the villagers unaware and scampering for their lives. It was reported in the early hours of 19.11.2021 around 5 am that the earth bund of Annamayya dam had breached.

The villagers literally lost everything, except the clothes on their person. Tens of houses in these villages downstream of the project were reduced to rubble. Tens of cattle heads were washed away. Nothing of the household items was left as the deluge gulped them. In Pulapathur village 13 In Mandapalle alone 12 and in Gundlur 5 people have been swept away in flooded Cheyyeru. An APSRTC bus fell into floodwater from Nandaluru Bridge on the Cheyyeru River killing 10 people. The Rajampet area witnessed heart-rending scenes with dead bodies of people being washed away in the floods due to a lack of advance alerts. The Chennai-Mumbai rail route that runs through the Kadapa district was shut as about 1.5 km long tracks got washed away near Nandaluru. Several kilometers of the railway line between Renigunta and Guntakal have been swept away. The tracks on the Nandalur-Rajampeta section of the Guntakal division of the South Central Railway in Andhra Pradesh have suffered damage due to incessant rains in the region and heavy flooding resulting due to it. As a result, many trains have been diverted, canceled, and partially canceled. The railway line between Kadapa and Rajampet was also damaged. Railway officials said the renovation work was underway and would take three days to complete. A total of 172 trains have thus been canceled. South Central Railway acted on a war foot to restore the badly damaged railway track between Nandalur – Hastavaram railway stations. Two tracks were badly hit for more than a km and the authorities set a target to restore the tracks in four days.

### **Incidents of Heavy Rains and Flood Situation**

Meanwhile, the Kadapa administration could not assess the death toll properly. Though 30 persons were reported as dead or missing ‘many bodies were not traced

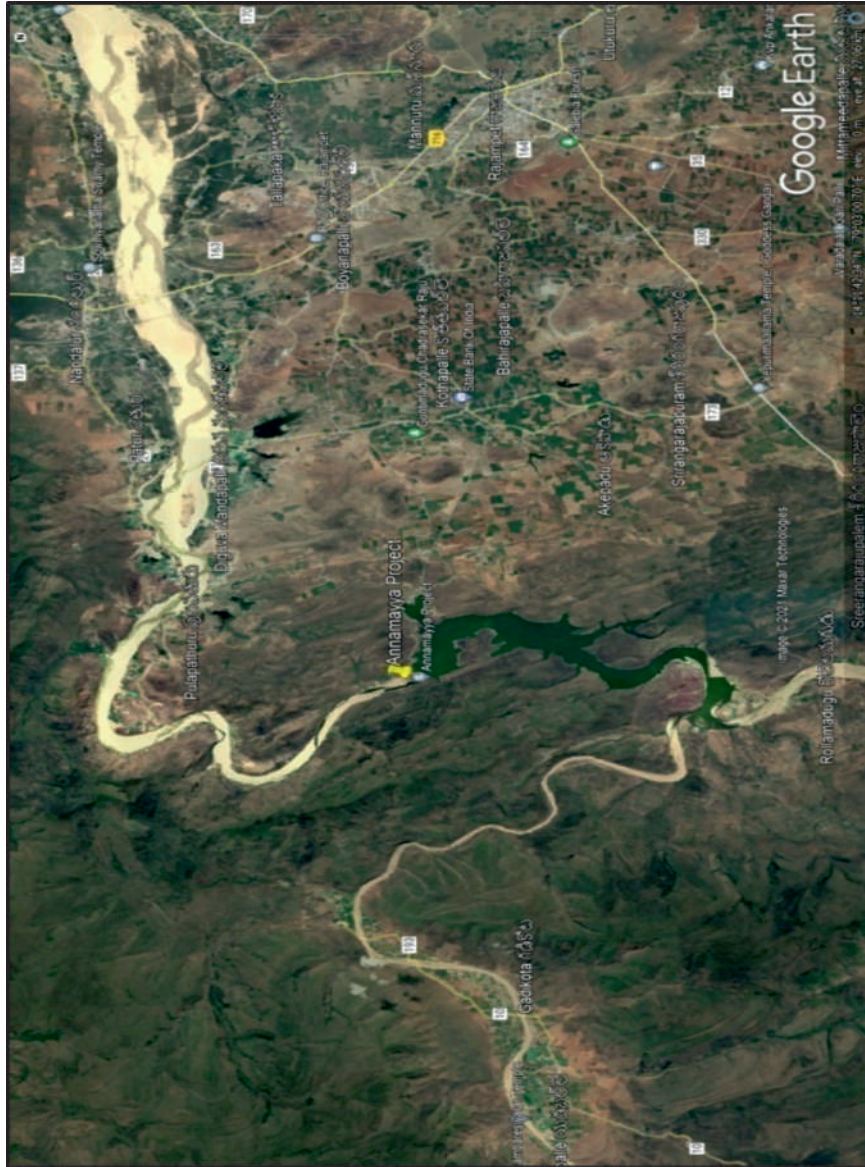


Photo 5: Rajampeta Between Nandalur Road

due to the heavy flow in the reservoir. The source said about 100 persons was missing in several parts of the YSR Kadapa district mostly due to the floods of the Annamayya project and there was heavy death toll. Rescue workers traced out 12 bodies and were searching for the missing people in the Rajampet area. The buses were stuck in flood waters in Mandpalle, Akepadu, and Nandalur villages. The passengers along with drivers and conductors had climbed on the top of the buses. While some were rescued by the local residents, 30 people were flooded away. The buses were stranded as the Cheyyeru stream overflowed, after receiving huge inflows due to breach in the bund of Annamayya irrigation project causing flash floods and inundating many villages including Gundluru, Seshamambapuram, and Mandpalle around Nandalur, Rajampet and other areas. The revenue officials were preparing the deceased list through the staff of Grama Sachivalayams and tahsildar offices under the Annamaiah projects downstream areas. So far, 14 bodies were recovered while the rescue teams continued the search (**Photo-1**). Manda Sreenivasulu (48) former Grama panchayat sarpanch of C. Kamdulavaripalle and his son Shyam Kumar (24), who were traveling in an RTC bus towards Rajampet were among the passengers of the RTC bus that got stuck in the floods in Cheyyeru. Syamkumar was set to take a flight to Kuwait. Sreenivasulu's body was traced after a day while Syamkumar's body was found a kilometer away after two days. Syamkumar had two children and his wife Lakshmi Devi pregnant. Three bodies were recovered from an RTC bus near Nandalur. Seven bodies were found in Gundluru while three bodies were pulled from Rayavaram areas.

The buses were stranded as the Cheyyeru stream overflowed, after receiving huge inflows from the Annamayya irrigation project where a bund was breached, causing flash floods and inundating many villages including Gundluru, Seshamambapuram, and Mandpalle around Nandalur, Rajampet and other areas. While two buses were stranded above the water, one bus, plying on the Rajampet-Nandalur route, was almost entirely submerged. Cheyyeru floods have cast doubts over the future of an upcoming national-level boxer, M. Vamsikrishna. All his hopes of securing a government job under the sports quota came crashing down after he lost his certificates in the floods. Like Vamsikrishna, several people in villages under the Annamayya project along the Cheyyeru River, lost their valuables, Aadhaar cards personal identification documents, land pattas, bank passbooks, passbooks and certificates education certificates, property documents, and pattadar passbooks of people losing. With nowhere to turn, they seek government aid in resolving the crisis. Vamsikrishna, in his early 20s, is a second-year degree student in Rajampet

and aspired to be a sportsperson ever since he was a child. Having received training in boxing and karate for several years, he won several medals at district, state and national levels. His love for combat sports did not come at the cost of his academics. “Cheyyeru floods dashed all my hopes. I lost my academic and boxing certificates. Without them, I don’t know what to do,” Vamsikrishna, son of farmer parents, rued after approaching officials and others who he thinks can help. The personal crisis came at a time when Vamsikrishna’s family lost their standing crop and their house was damaged in the floods. His parents had cultivated paddy on their four-acre land investing thousands of rupees. They had stored 70 bags of paddy in the house, all of which washed away after the water came gushing into their home. Narrating his sorry tale, he urged the State government to help him get new certificates so that he can fulfill his ambitions of representing the state in a national forum. “The river course changed but the dam breach was what caused the real destruction. We still moved some 600 people to safety,” he said. “Yes, it was a major calamity, the scale of which could not be imagined,” Raju added (**Photo-2**).

### **Prevention and Mitigation Measures**

Floods Action Plan at Mandal Level to be taken up in the event of warning immediately on receipt of the Preliminary Cyclone warning, an emergency control room will be opened in the office of the Tahsildar to ensure all instructions contained in the Cyclone Plan are communicated to all concerned and the plan is put into operation immediately. MPDOs and all the Mandal level officers have to be in touch with the Tahsildar and take the immediate necessary action as per the direction received from Supervisory Officer/Tahsildar and Senior Officer from time to time.

### **Damage to Agriculture and Horticulture Crops**

Heavy rain and floods in four districts of Andhra Pradesh have damaged agriculture and horticulture crops spread over eight lakh hectares, officials said. Agriculture department officials said crops were washed away due to breaches in the bunds of irrigation projects like the Annamaya project and the Cheyyeru reservoir in the Kadapa district. At least 3 dead, Nearly 30 people missing in a flash flood on Rajampeta revenue division of Y.S.R Kadapa.

### **Conclusion**

The Andhra Pradesh state has indeed seen one of the worst flood disasters in recent years (Nov.2021) causing large-scale destruction in Kadapa, Chittoor, Anantpur, and Nellore Districts. Annamayya project dam was breached after

heavy water flow in Cheyyeru River. Several people were killed and some went missing dozens of homes were washed away and many of temples of archeological importance were submerged. One of the basic problems is in designing and executing the projects. Pincha and Annamayya project on Cheyyeru River caused lot of damage to the bunds of the projects due to excess flow of water and a lower storage capacity. Furnishing of the information on inflows and outflows of minor and medium irrigation projects is very important. Appropriate designing with the requisite holding capacity facilitates for storage of water and restricts outflow of water. The weather forecast mechanism is also a big tool for the purpose. However, the destruction on the ground is largely due to anthropogenic reasons and unscientific operations. But scientific, efficient, and accountable operations of dams and irrigation projects can help floods don't turn into a disaster. This precautionary check facilitates a great preparedness to face the new rainfall pattern leading to floods and for vacation of the people from the flood prone area. Thus a strategic, scientific approach coupled with the usage of technological sophistication for appropriate structuring, designing and storing will convert Cheyyeru River as a major source of water for irrigation, drinking in Kadapa, Nandaluru, Rajampeta.

## References

- C. Ramachandraiah (2009): Coping with urban flooding a study of the 2009, Kurnool floods, India. Published international institute for Environment and development (IIED), Volume-232, 431-446. Do.10.1177/0956247811418733
- Collector and Disaster Magistrate: District Disaster Management Plan – 2016, Kadapa, Kadapa district, Andhra Pradesh.
- R. Bhavani (2014): Mapping River Inundation – A case study on River Pennar from Penna Ahobilam Balancing Reservoir (PABR) to Midpennar Reservoir (MPR) published in international journal of innovative research in science, Engineering and Technology – Val.3, Issue 12, December 2014, ISSNO: 2319-8753
- WAPCOS: Pennar River Final Feasibly Report – Stage-1 (Chapter – 5)
- Naveen Reddy, Anakapalli (2021), Andhra Pradesh – Dam Induced flood Disaster in November-2021, 5th December 2021, South Asia Network on Dam, Rivers and People (SANDRP)
- Indian Express: Over flowing rivulets and streams flooded several residential localities in Ananthapur, Chittoor and YSR Kadapa district. While the district of Nellore and Prakasam are witnessed intermittent rains published in the Indian Express, 19th November 2021. [www.newindianexpress.com](http://www.newindianexpress.com)
- Hindustan Times: Many still missing in Andhra floods. November-2021, [www.Hindustantimes.com/Indiannews](http://www.Hindustantimes.com/Indiannews)
- India Time News Desk Andhra Pradesh: At least 8 dead, 12 missing in flash flood in YSR Kadapa District, Published 19th November 2021, [www.Indianews.com](http://www.Indianews.com)
- Kadapa District Administration: General plan and Hazard, Vulnerability and capacity analysis of Kadapa District. Volume –I District Disaster Management Plan of Kadapa District: Supported by United Nations Development Programme, India.

- Kadapa District Administration: Preparedness, Prevention, Mitigation, Disaster risk reduction and climate change action plan. Volume-II, Supported by United Nations Development Programme, India.
- Kadapa District Administration: Response and Recovery Plan - Volume-III, Supported by United Nations Development Programme, India.
1. Joanne Matherin: Floods, Dams and Levees. Rourke Publishers Vero Beach, Florida-32964
  3. R. Balaram, S. Ramanaiah and Jagadeswara Rao (2021): Problems involved in the sustainable water supply from Annamayya and Mallemadugu Reservoirs in Kadapa and Chittoor District of Galeru – Nagari, Sujala Sravanthi (GNSS) project, Andhra Pradesh, India. Published in Science Technology and Development Journal Volume-X, issue III, March-2021.
- . Jamjam Kesav (2021): Urban Floods – A case Study of Hyderabad. Tata Institute of Social Science.
- . R. Bhavani (2014): Mapping River Inundation – A case study on River Pennar from Penna Ahobilam Balancing Reservoir (PABR) to Midpennar Reservoir (MPR) published in international journal of innovative research in science, Engineering and Technology – Val.3, Issue 12, December 2014, ISSN: 2319-8753
- Arun B Shrestha and Sagar R Bajracharya (2013): Case Studies on Flash Flood Risk Management in the Himalayas. In support of specific flash flood policies, International Centre for Integrated Mountain Development, Kathmandu, Nepal: IS BN – 978, 92-9115269, trinted, 978. 9291152704 (elranse)
- Micro Small & Medium Enterprises, Govt. of India: Brief Industrial profile of YSR Kadapa District – MSME – Development Institute (Branch), F-19, D-Block, Autonagar, Visakhapatnam.
- Armando Apan (USQ) Diane V Keogh (USQ), David King (JCV) Melanie Thomas (JCU), Shahbas Mushtaan (USQ), Peter Badohley (BOM): The 2008 Floods in Queens Land : A Case Study of Vulnerability, Resilience and ADAPTIVE CAPACITY.
- Patil Sardar A and Patil Shilpa S (2011), Socio-Economic impacts of flood disaster in upper Krishna Basin; A case study of village Pundi (Tal, Palus Dist., Sangli), proceeding of National Conference on Population, Environment and Tourism (ISBN: 978-81-922415-0-0)

--N. Sreedhara Naidu  
Urban Planner  
State Level Technical Cell (SLTC)  
APTIDCO, 4th Floor NTR Administrative Block  
P.N Bus Station, Vijayawada  
NTR District, Andhra Pradesh -520013



## **EVALUATING ESG PRACTICES AND THEIR IMPACT ON REGIONAL DEVELOPMENT: A STUDY OF TIER-1 AUTOMOBILE COMPANIES AND INVESTORS' PREFERENCES**

Sumit Kumar, Sharma Mona, Santosh Bhukal and Deepak Bansal

### **Abstract**

The integration of Environmental, Social, and Governance (ESG) practices into businesses is attracting considerable attention as a means of achieving sustainable development. This study investigates the ESG variables that are given extraordinary importance by the tier-1 automobile firms and parts suppliers situated in the National Capital Region (NCR) of India, notably in Gurugram, Faridabad, New Delhi, and Noida. Data collected from important industry players using a comprehensive questionnaire to determine the ESG aspects that are given priority and the effects of these practices on regional socio-economic and environmental situations. In addition, the study examines the preferences of investors concerning ESG indicators while making investment choices. The corporations prioritize environmental indicators, such as reducing carbon footprint and improving energy efficiency, above everything else. They then prioritize social factors, such as labour practices and community engagement. Transparency and ethical conduct are important aspects of governance. The analysis indicates that the adoption of ESG principles in the NCR region has resulted in significant modifications in local environmental conditions and has strengthened regional economic growth by generating employment opportunities and advancing infrastructure construction. Furthermore, investors have a strong inclination towards companies that prioritize better governance and social responsibility, and their choices closely match the focus areas of these companies. These observations emphasize the crucial significance of ESG factors in influencing regional progress and emphasize the mutually beneficial connection between company strategies and investor demands. The study's findings have important implications for policymakers, indicating that promoting ESG practices can contribute to sustainable regional development. Further investigation is needed to examine the long-term effects of incorporating ESG factors on the socio-economic dynamics of specific regions.

## **Introduction**

Environmental, Social, and Governance (ESG) policies have become crucial elements of business strategy, indicating a company's dedication to sustainable development and ethical behaviour (Gillan et al., 2021). The automotive industry, specifically Tier-1 auto ancillaries and components suppliers, has a significant impact on regional economic ecosystems, affecting both the environment and socio-economic conditions (Clark et al., 2015). This study specifically examines the National Capital Region (NCR) of India, which includes Gurugram, Faridabad, New Delhi, and Noida. The objective is to get insights into the ESG goals of firms in this region and what part of ESG is getting more attention. Contemporary research emphasizes the increasing significance of ESG concerns in attracting investment and improving business reputation (Friede et al., 2015). Nevertheless, there is a significant deficiency in research that establishes a connection between environmental, social, and governance (ESG) practices and the consequences of regional development, especially in quickly industrializing regions like the National Capital Region (NCR) (Kumar et al., 2019). This study seeks to address this deficiency by examining the ESG indicators that are given priority by Tier-1 automotive businesses and components suppliers in the NCR, and the impact of these practices on regional socio-economic and environmental conditions. This research identifies the ESG issues that are considered most important by key industry stakeholders through a thorough questionnaire. According to Porter & Kramer (2011), the main focus should be on environmental sustainability, including reducing carbon footprint and improving energy efficiency. This is followed by concerns about social issues such as labour practices and community engagement.

In addition, the study investigates the correlation between investor preferences and business ESG priorities, highlighting a significant focus on environmental and social factors (Eccles et al., 2014). The research findings have important implications for policymakers and corporate leaders, indicating that implementing strong environmental, social, and governance (ESG) standards can promote sustainable regional growth. Focusing on the 'Environmental' part of ESG can help in the significant reduction of pollution in the NCR region. By connecting corporate strategies with ESG goals, companies can improve their competitive advantage and make a beneficial impact on the economic and environmental well-being of the region. Further investigation is needed to examine the lasting effects of incorporating ESG factors on the development of specific regions. This research aims to find out which part of ESG is getting more attention from the companies in

their daily business activities. Also, it focuses on which part of the ESG theme gets more priority while making an investment decision.

### **Study Region**

This study focuses on the National Capital Region of India, which includes Gurugram, Faridabad, New Delhi, and Noida. NCR is a prominent centre for industry and commerce, renowned for its high number of leading vehicle firms and suppliers of automotive parts (Ramasamy & Yeung, 2010). Gurugram and Noida have emerged as prominent hubs for automobile manufacturing and business headquarters, making significant contributions to the local economy (Dash & Chanda, 2017). Faridabad, known for its generous industrial sector, and New Delhi, serving as the capital city, contribute significantly to the region's economic vitality. The selection of the NCR as the research region is driven by its distinctive combination of sophisticated industrial infrastructure, substantial corporate representation, and varied socio-economic environment (Mukherji & Tripathi, 2020). The rising urbanization and industrialization of this region offer an excellent opportunity to study the application and effects of ESG principles in the automotive industry. Furthermore, due to its significant role in India's economic structure, the NCR is a crucial area to examine regional growth influenced by corporate sustainability initiatives (Chatterjee & Kumar, 2016). The study utilizes data obtained from questionnaires issued to important industry participants in these locations, documenting their viewpoints on ESG priorities and practices. This methodology guarantees a thorough comprehension of how environmental, social, and governance factors are incorporated into corporate strategy and their subsequent effects on specific regions. Prior studies highlight the significant impact of ESG measures on improving both the environmental quality and socio-economic aspects of a region (Vijayalakshmi & Raj, 2019). This study intends to provide significant insights for policymakers and corporate leaders by examining the regional consequences of ESG practices, with a specific focus on the NCR. The discoveries can provide insights for developing strategies to advance sustainable development and regional planning, by linking company interests with wider societal and environmental goals.

### **Objective**

- (1) To determine the ESG indicators that are emphasized by Tier-1 automobile firms and component suppliers in the NCR region.

- (2) To assess which part of ESG has been given more weightage by the companies working in the NCR region.
- (3) Analyze investor preferences to determine the Environmental, Social, and Governance that investors prioritize when making investment choices.

### **Database and Methodology**

This study is based on primary data obtained from two thoroughly designed questionnaires distributed to Tier-1 automobile parts manufacturers and suppliers in the NCR of India, which includes Gurugram, Faridabad, New Delhi, and Noida. The initial survey, targeting corporate delegates, centred on finding the ESG indicators given the highest priority within their operations. The second survey was circulated among investors to assess their preferences regarding ESG parameters in their investment decision-making process. A total of 110 responses were received for the questionnaire shared with the auto ancillary companies. About 85 companies which belong to the NCR region were selected for this study. Similarly for the questionnaire for ESG investors, a total of 105 responses were received and out of these 105 only 70 were chosen for study that particularly belongs to the NCR region. Both email and direct interviews were employed to maximize the response rate. Both surveys consisted of a combination of closed-ended and open-ended items. Closed-ended questions employed a simple checklist method to choose ESG indicators, whereas open-ended questions let respondents provide detailed explanations about specific habits and preferences. The questionnaire for auto ancillaries consists of 40 questions while the questionnaire for the investors consists of 27 questions. The gathered data was examined utilizing both quantitative and qualitative methodologies. The quantitative study was carried out by calculating the percentage of ESG indicators followed by the companies and prioritized by the investors. The qualitative data obtained from open-ended responses was subjected to thematic analysis to identify and extract recurring themes and get valuable insights. Ensuring the validity and reliability of the data, the questionnaires underwent pre-testing with a small sample of respondents and were then amended based on their input. In addition, triangulation was used to verify consistency and robustness by comparing the findings from both groups of respondents.

**Ethical Considerations:** Both the respondent firms and the investors agreed on the condition of disclosing neither their personal information nor the name of the firm and investor. Any of such information is not utilized or disclosed in the study which may highlight the name of the company or affects its business

in any form. The study ensured the preservation of confidentiality and anonymity for the respondents.

## Results and Discussion

This section offers an in-depth examination of the results obtained from the surveys carried out with Tier-1 vehicle firms, parts suppliers, and investors who prioritize environmental, social, and governance indicators. The results uncover noteworthy patterns and inclinations in ESG practices, emphasizing the domains where firms are falling behind, specifically about environmental considerations.

### Emphasis on Environmental, Social, and Governance ESG in Leading Auto-ancillaries and Component Suppliers

The survey results are shown in **Table-1**. Tier-1 automobile businesses and parts suppliers prioritize governance and social indices, achieving ratings of 92% and 82% respectively **Table-1**. Environmental influences are only about 68%. This disparity indicates a necessity for a more robust emphasis on environmental sustainability within these companies.

Table-1: ESG Indicators followed by the tier-1 Auto Ancillaries in Business Practices.

ESG aspect	Percent of indicators followed by the Firms
Environmental	68
Social	82
Governance	92

Source: Authors

## Governance

The governance high score signifies that these companies are placing a strong emphasis on ethical procedures, transparency, and adherence to rules. This is consistent with the conclusions of Smith et al. (2020), who observed that strong governance frameworks are essential for preserving investor confidence and ensuring the long-term sustainability of businesses. Effective governance practices encompass well-defined policies about business ethics, systems for accountability, and extensive structures for reporting. Furthermore, effective governance can reduce the risks linked to company scandals and failure to comply with regulations, which can result in significant financial and reputational consequences.

Effective governance is of utmost importance in the automotive industry, especially in areas such as Gurugram and Faridabad, due to the intricate regulatory framework and the significant implications related to production standards and safety laws.

### **Social**

The social indicator, with a score of 82%, demonstrates the companies' dedication to social responsibility, the well-being of employees, and active involvement in the community. This aligns with the research conducted by Sroufe & Gopalakrishna-Remani (2019), which highlighted the significance of social sustainability in improving business reputation and stakeholder relationships. Social sustainability in the automobile industry can be observed through policies that ensure fair treatment of workers, adherence to health and safety regulations, engagement in community outreach initiatives, and efforts to foster diversity and inclusion. In regions such as the NCR, encompassing New Delhi, Gurugram, Faridabad, and Noida, where there is a wide range of socio-economic conditions, enterprises that prioritize social indicators can bring about significant advantages for the community. These benefits may include the creation of employment opportunities, enhancement of skills, and improvement of living standards. The focus on social elements not only benefits the local population's well-being but also cultivates a committed and driven staff, leading to increased productivity and creativity inside the companies.

### **Environmental**

Although there is a strong focus on governance and social elements, the environmental score of 68% indicates that there is still huge potential for enhancement. Ensuring environmental sustainability is vital for minimizing the carbon impact and meeting global climate objectives. Elemure et al. (2023) provided evidence that environmental policies are frequently given lower priority because of their immediate financial consequences, even when they offer long-term advantages. Environmental sustainability in the automobile industry entails the adoption of measures aimed at minimizing the negative effects on the environment. These measures include the reduction of emissions, the efficient utilization of resources, and the promotion of recycling and waste management. In areas such as the NCR, where industrial operations have substantial environmental impacts, corporations must implement more rigorous environmental regulations. The delay in implementing environmental practices can be ascribed to issues such as the substantial upfront expenses of green technologies, the absence of regulatory enforcement, and insufficient recognition of the enduring advantages of environmental sustainability.

### Investor's ESG Indicator Preferences

The second survey was conducted to gain insight into the preferences of investors regarding ESG metrics. According to the findings, while making investment choices, investors consider governance (94%), social (87%), and environmental (76%) concerns shown in **Table-2**.

Table 2: Shows the percentage of different factors of ESG that investors prioritise while making an investment decision

ESG aspects	Inclusion percentage of ESG factors by Investors into investment decisions under ESG
Environmental	76
Social	87
Governance	94

Source: Authors

### Governance

Investors place a high priority on governance, as evidenced by a score of 94%, indicating their preference for companies that have robust governance systems. This is consistent with the research conducted by John et al., 2018, which discovered that governance plays a crucial role in investment choices since it affects risk management and corporate integrity. Investors view strong governance as a sign that a company can effectively handle risks, adhere to rules, and uphold ethical standards.

Implementing efficient governance processes can improve a company's standing, attract investment, and result in more advantageous financing terms. In areas such as the NCR, where the regulatory landscape can be difficult, implementing robust governance measures can offer investors the confidence that enterprises are well-managed and capable of withstanding any risks.

### Social

The 87% social score among investors underscores the growing significance of social aspects in financial choices. Investors are placing greater importance on social factors, including labour practices and community impact, due to their association with the long-term viability of businesses (Berry & Junkus, 2013). Socially responsible investments are believed to carry reduced risks and the possibility for increased returns because of their beneficial influence on relationships with

stakeholders and the reputation of the company. Investors pay close attention to how companies handle their human resources, community engagement, and social influence. In areas such as the NCR, where there are significant differences in socio-economic status, enterprises that exhibit robust social responsibility are more likely to earn the trust and support of investors. This trend signifies a more extensive change in investment techniques, where social impact is being included as a crucial element of sustainable investment.

### **Environmental**

Investors ranked environmental considerations the lowest, with a score of 76%. This suggests that while environmental sustainability is significant, it is not as crucial as governance and social concerns. Environmental sustainability is typically not prioritized unless there are explicit governmental or commercial incentives. Investors may be reluctant to give priority to environmental considerations because they believe that green investments involve higher expenses and uncertain returns (Flammer, 2013). Nevertheless, with the growing worldwide recognition of climate change and environmental deterioration, investors are gradually acknowledging the financial consequences linked to neglecting the environment. In areas such as the NCR, where environmental concerns like air pollution and water scarcity are widespread, companies must embrace more proactive environmental policies. Although the current attention from investors is not primarily on environmental factors, future trends may lead to a stronger emphasis on environmental sustainability as legislative frameworks develop and market incentives become more prominent.

### **Geographical Context and Significance**

The NCR (New Delhi, Gurugram, Faridabad, and Noida) and its surrounding districts have a distinct geographical context, which is marked by specific socio-economic and environmental concerns. The industrial operations in the region, such as manufacturing industries, have substantial environmental consequences. It is essential to prioritize addressing the environmental delay identified in the study to achieve sustainable development in these areas.

### **Ecological Consequences**

Metropolitan areas like the National Capital Region (NCR) encounter significant environmental issues, including limited water resources, air pollution, and deterioration of land quality. The delay in implementing environmental policies among tier-1 Auto component makers could worsen these difficulties. It is crucial to

incorporate strict environmental practices to reduce the negative effects of industrial activities on the local ecosystem. Efficient management of industrial emissions, waste disposal, and resource consumption is necessary to safeguard the region's natural resources and guarantee long-term environmental sustainability (Patel et al. 2023). Efforts to enhance environmental practices can involve the adoption of cleaner industrial technology, the improvement of waste management systems, and the implementation of complete environmental impact assessments. Implementing these steps can effectively reduce the adverse effects of industrial activities on the local environment and significantly enhance the overall health and well-being of the inhabitants of the NCR.

### **Socioeconomic Development**

Enhancing social indicators can bolster the socio-economic progress of the region. Implementing improved labour practices, engaging with the community, and taking responsibility for social issues can have a positive impact on local communities (Kumar et al., 2019). In areas such as the National Capital Region (NCR), where there are considerable differences in social and economic conditions, business efforts focused on enhancing education, healthcare, and infrastructure can have a dramatic and beneficial impact on the local populations. Companies that place social sustainability as a top priority can establish a business climate that is more inclusive and equal, resulting in enhanced social cohesion and stability. These endeavours can additionally improve the skills and productivity of the local workforce, so contributing to the economic growth and development of the region.

### **Implications for governance and policy**

The significant focus on governance is promising, indicating that enterprises in locations such as NCR are in a favourable position to adhere to regulatory frameworks and gain the trust of investors. The emphasis on governance can effectively facilitate the execution and compliance of policies, which is essential for achieving sustainable development (Rao et al., 2016). Implementing efficient governance processes can enhance the ease of engagement with regulatory authorities, guaranteeing adherence to environmental and social regulations. Enhancements in governance can also promote increased openness and accountability in corporate activities, thereby mitigating the potential for corruption and bolstering public confidence in the business industry. These advantages can enhance the stability and appeal of the investment environment in places such as NCR, hence fostering sustainable economic growth.

## **Conclusion**

This study emphasizes the growing significance of ESG indicators in the automotive industry, namely among Tier-1 automobile manufacturers and component suppliers. The survey results highlight the necessity of adopting a well-rounded approach to ESG standards among top-tier vehicle businesses and component suppliers. Although governance and social factors have been adequately addressed, there is an urgent requirement to improve environmental practices. The significance of strong governance and social responsibility is further emphasized by the choices of investors. Incorporating these discoveries within the geographical setting of areas such as the NCR highlights the crucial significance of implementing sustainable industrial methods for regional progress. Subsequent studies should prioritize the creation of tactics to enhance environmental sustainability in the automotive industry, considering the distinctive difficulties and prospects in places such as NCR. To foster sustainable practices, policymakers and industry stakeholders must work together to establish a favourable climate that harmonizes economic growth with environmental and social obligations. The findings from this research enhance our comprehension of the ESG framework in the automotive sector, providing significant direction for both professionals and policymakers to focus on environmentally sustainable business practices. Subsequent studies should investigate the ever-changing characteristics of ESG priorities and their influence on the financial success of companies in various industries. By consistently prioritizing and promoting ESG principles, the sector can actively promote sustainable growth and cultivate a future that is both more resilient and egalitarian.

## **References**

- Berry, T. C., & Junkus, J. C. (2013). Socially responsible investing: An investor perspective. *Journal of Business Ethics*, 112, 707-720.
- Chatterjee, B., & Kumar, V. (2016). The economic geography of India: Interaction between land use and economic development. *Journal of Economic Geography*, 16(1), 45-72.
- Clark, G. L., Feiner, A., & Viehs, M. (2015). From the stockholder to the stakeholder: How sustainability can drive financial outperformance. Available at SSRN 2508281.
- Dash, A., & Chanda, R. (2017). Indian Firms in Automotive Global Value Chains: Sectoral Analysis. Centre for WTO Studies, Indian Institute of Foreign Trade.
- Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, 60(11), 2835-2857.
- Friede, G., Busch, T., & Bassen, A. (2015). ESG and financial performance: aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investment*, 5(4), 210-233.
- Flammer, C. (2013). Corporate social responsibility and shareholder reaction: The environmental awareness of investors. *Academy of Management journal*, 56(3), 758-781.

- Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms' environmental, social and governance (ESG) choices, performance and managerial motivation. *Journal of Financial Economics*, 142(2), 1-26.
- John, K., Litov, L., & Yeung, B. (2008). Corporate governance and risk-taking. *The journal of finance*, 63(4), 1679-1728.
- Kumar, S., Singh, R., & Sharma, P. (2019). Regional economic growth and sustainability: The case of Indian states. *Environmental Economics and Policy Studies*, 21(2), 123-145.
- Mukherji, A., & Tripathi, S. (2020). Urbanization and economic growth in India: An examination of causality. *Journal of Regional Science*, 60(4), 742-767.
- Patel, S. K., Sharma, A., Barla, A., Tiwari, A. K., Singh, R., Kumar, S., & Singh, G. S. (2023). Socio-ecological challenges and adaptation strategies of farmers towards changing climate in Vindhyan highlands, India. *Environmental Management*, 1-17.
- Porter, M. E., & Kramer, M. R. (2011). Creating shared value. *Harvard Business Review*, 89(1/2), 62-77.
- Ramasamy, B., & Yeung, M. (2010). The determinants of foreign direct investment in services. *World Economy*, 33(4), 573-596.
- Rao, P., et al. (2016). Governance and Policy in the Deccan Region. *Journal of Regional Studies*, 38(3), 270-290.
- Smith, A., Jones, B., & Taylor, C. (2020). Governance Structures and Investor Trust. *Journal of Business Ethics*, 123(2), 345-358
- Sroufe, R., & Gopalakrishna-Remani, V. (2019). Management, social sustainability, reputation, and financial performance relationships: An empirical examination of US firms. *Organization & Environment*, 32(3), 331-362.
- Vijayalakshmi, S., & Raj, K. (2019). Income and vehicular growth in India: A time series econometric analysis. Bangalore, India: Institute for Social and Economic Change.
- Elemure, I., Dhakal, H. N., Leseure, M., & Radulovic, J. (2023). Integration of lean green and sustainability in manufacturing: a review on current state and future perspectives. *Sustainability*, 15(13), 10261.

--Sumit Kumar  
 Department of Environmental Science &  
 Engineering  
 Guru Jambheshwar University of Science &  
 Technology  
 Hisar (Haryana)

--Mona Sharma  
 Department of Environmental Studies  
 School of Interdisciplinary and Applied  
 Sciences  
 Central University of Haryana  
 Mahendergarh (Haryana)

--Santosh Bhukal  
 Department of Environmental Science &  
 Engineering  
 Guru Jambheshwar University of Science &  
 Technology  
 Hisar (Haryana)

--Deepak Bansal  
 JBM Group  
 Gurugram (Haryana)



## **DYNAMICS OF AGRICULTURAL INFRASTRUCTURE AND DEVELOPMENT IN RAJASTHAN**

Dr. Pramila Kumari Sharma

### **Abstract**

Rajasthan is the agriculture dominant state in present India in spite that the role of agriculture is more role in GDP of the state. Rajasthan is the largest state in term of area where it contributes 10.41 percent area, 5.67 percent of population, 10.70 percent of livestock of the country. The state of Rajasthan has very much disparity in term of agriculture productivity because there are 10 agro climate zones and it affected the productivity of the crops. The paper is tired to examine consequence of many factors on agriculture during the year 1980-81 to 2019-20. This paper deals with agriculture development in Rajasthan which function many exogenous factors like modern mechanization, use of fertilizers facilities, improved seeds, cropping intensity etc. This study based on secondary data of agriculture statistics of Rajasthan. The parameters estimated from the multiple linear regressions between elicited districts level factors sources by principle component analysis and used K.M.O. and Bart lefts test to see the strength of the relationship among variables.

### **Introduction**

Agricultural Development refers to the gradual shift in farming best practices. Agricultural Development is defined as the process that creates the conditions for the fulfillment of agricultural potential. Those conditions include the accumulation of knowledge and availability of technology as well as the allocation of inputs and outputs. The status of agricultural development is assessed on the basis of the agricultural infrastructure reflected in the indicators like extent of irrigation, irrigation intensity, cropping intensity, use of packaged program etc. Agriculture growth is very important for a developing country like India because its large part of population depends on this. Agriculture occupied a place of pride in India's national economy. It has a share of 32 percent in the Gross Domestic Product (GDP) of the country. The economy of study area is agriculture based and more than 70 percent population is dependent upon this sector. Agricultural development in any region means by and large an improvement of land productivity with the

application of high degree of inputs. Agricultural development should be assessed not only by levels of productivity or trend in agricultural production but also with reference to various inputs like irrigation, fertilizers, improved seeds and extent of cultivated area. The role of agriculture in influencing economic outcomes has been well understood at micro-level. If agriculture sector develops then it will be helpful for the further development of industries and service sector as there are intense interrelationships among these sectors of the economy. If agriculture sector develops then it will raise the level of income of the planners and hence their living standard and quality of life will be enhanced which makes the human development level better of those people who are totally dependent of agriculture. Better agriculture will lead to more positive psychological effect on the farmers and as a result their productive capacity will be increased. It is well accepted by several policy makers of India that if we want to develop then we have to develop the rural agricultural sector first because a huge part of population depends on it. There is a need of second green revolution in the country. All knows that a society develop according to Pendulum theory of development. We have to return on that place from where we have starts. Since the limits to growth model will be applicable in India and the industrial and service sector develop at a faster pace than agricultural sector after a limit the growth of these sector will be cease and the only way which will suction the growth of economy will be agriculture. More, a small portion of Indian population works in industrial and service sector therefore if we want to develop India or the distribution should be equitable than we have to develop the agriculture. Now a day's various new concepts in agriculture is accruing like organic farming, contract farming and many more will develop the outcomes of agriculture and hence develop the quality of life of those people who are directly or indirectly depends on agriculture for their childhood. Therefore, it is very important to analysis the determinants and levels of agricultural development in study area. Before we proceed to analyze the agricultural development, it will be useful to describe the agricultural scenario of the study area.

### **Study Region**

The geographic features of Rajasthan are the Thar Desert and the Aravalli Range, which runs through the state from southwest to northeast, almost from one end to the other, for more than 850 kilometers (530 mi). Mount Abu lies at the southwestern end of the range, separated from the main ranges by the West Banas River, although a series of broken ridges continues into Haryana in the direction of Delhi where it can be seen as outcrops in the form of the Raisina Hill and the

ridges farther north. About three-fifths of Rajasthan lies northwest of the Aravallis, leaving two-fifths on the east and south direction. The northwestern portion of Rajasthan is generally sandy and dry. Most of this region are covered by the Thar Desert which extends into adjoining portions of Pakistan. The Aravalli Range does not intercept the moisture-giving southwest monsoon winds off the Arabian Sea, as it lies in a direction parallel to that of the coming monsoon winds, leaving the northwestern region in a rain shadow. The Thar Desert is thinly populated; the town of Jodhpur is the largest city in the desert and known as the gateway of thar desert. The desert has some major districts like Jodhpur, Jaisalmer, Barmer, Bikaner and Nagour. This area is also important defense point of view. Jodhpur airbase is India's largest airbase and military, BSF bases are also situated here. A single civil airport is also situated in Jodhpur. The Northwestern thorn scrub forests lie in a band around the Thar Desert, between the desert and the Aravallis. This region receives less than 400 mm of rain in an average year. Temperatures can sometimes exceed 54 °C in the summer months or 129 degrees Fahrenheit and drop below freezing in the winter. The Godwar, Marwar, and Shekhawati regions lie in the thorn scrub forest zone, along with the city of Jodhpur. The Luni River and its tributaries are the major river system of Godwar and Marwar regions, draining the western slopes of the Aravallis and emptying southwest into the great Rann of Kutch wetland in neighboring Gujarat. This river is saline in the lower reaches and remains potable only up to Balotara in Barmer district. The Ghaggar River, which originates in Haryana, is an intermittent stream that disappears into the sands of the Thar Desert in the northern corner of the state and is seen as a remnant of the primitive Saraswati River.

### **Objectives**

- (1) To examine the levels of agricultural development in the Rajasthan
- (2) To analyse indicators of agricultural development in study region.

### **Database and Methodology**

The secondary data for the present research work has been taken at year of 1980-81, 2019-20, were obtained from the Rajasthan statistical abstract, Jaipur. Overall data have been analyzed on the basis of category wise all district of Rajasthan. To explain the relationship between Agriculture development level and some selected indicators, the statistical tools of correlation, composite value, Un-standardized coefficients, rotated component matrix and at last find out results of the regression model.

### Districtwise Levels of Agricultural Development

Agricultural development means is to achieve the required amount of agricultural production and a high rate of economic growth in order to bring out a marked improvement in the standard of living of the people. By bringing about the changes in its techno-institutional resources, study area in Rajasthan state have increased their production of food grains and raw materials to agro-based industries. To examine the levels of agricultural development in the Rajasthan state the district is chosen as the unit area of the study. In order to assess the level of agricultural development sixteen indicators have been taken into account. These indicators are- Irrigation Extent (IE), Irrigation Intensity (II), Cropping Intensity (CI), Percent Area Under Improved Seeds (IS), Number of Livestock Per Hectare of NSA (LS), Percent of Agricultural Workers to Total Workers (AW), Number of Pump Sets Per Hectare (PS), Number of Tractors Per Hectare (NT), Consumption of Fertilizer (CF), Percents of Scheduled Caste Population (SC), Percent of Scheduled Tribe Population (ST), Literacy Rate (LR), Productivity of Land (PL), Labour Productivity (LP), Percent Area Under Cash Crops (CC) and Per Capita Agricultural Output (AO). 'Level of agricultural development has been measured by composite value of above sixteen indicators of agricultural development of the concerned districts and are grouped into the five categories viz. very high, high, medium, low and very low level of agricultural development. **Table-1** reveals the district wise level of agricultural development of Rajasthan in 1980-81 and 2019-20.

Table-1: Levels of Agricultural Development in Rajasthan

Category	Index Value	1980-81		2019-20	
		Rajasthan		Rajasthan	
		1	2	1	2
Very Low	<0.23	4	15.38	4	12.50
Low	0.23-0.35	8	30.77	7	21.88
Medium	0.36-0.48	9	34.62	13	40.63
High	0.49-0.61	3	11.54	4	12.50
Very High	>0.61	2	7.69	4	12.50
Total	26	100.0	32	100.0	

Source: Directorate of Economics and statistics, jaipur

Note: (a) Number of Districts (b) Percents to Total Districts Source: Computed

### **Very High Level of Agricultural Development**

In 1980-81 two districts of (Ganganagar and Bharatpur) Rajasthan were under this category. In 2019-20, 12.50 percents districts of Rajasthan i.e. four districts Ganganagar, Bundi, Kota and Bharatpur were under this category. The main reasons for very high level of agricultural development are developed infrastructure, well developed irrigational facilities, fertile soil, and high yielding variety of seeds and adoption of the advance farm technology by farmers.

### **High Level of Agricultural Development**

Alwar, Bundi and Chittorgarh districts of Rajasthan had this category in 1980-81, while in 2019-20, 12.50 percents districts of Rajasthan were under this category. Alwar, Dausa, Dholpur and Hanumangarh. The high level of Agricultural development was due to the presence of gentle gradient of land, availability of irrigational facilities and developed agricultural infrastructure.

### **Medium Level of Agricultural Development**

More than 34 percents districts of Rajasthan were haying this category in 1980-81. According to **table-1**, in 2019-20. About 44 percents districts of Rajasthan were under this category. These districts Banswara, Baran, Bhilwara, Jaipur, Jhalawar, Jhunjhunu, Karuali, Rajsamand, Sawai Madhopur, Sikar, Sirohi and Udaipur of Rajasthan. Here rugged physiography, moderate fertile soils, less irrigation facilities, moderate consumption of fertilizers presence of seasonal torrents etc. were the main reasons for medium level of agricultural development.

### **Low Level of Agricultural Development**

Low level of agricultural development was recorded in Ajmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Nagaur, Sikar, Tonk districts of Rajasthan state in 1980-81 whereas Ajmer, Dungarpur, Jodhpur, Nagaur, Pali, Tonk (Rajasthan) districts had this category in 2019-20; The presence of rocky surface, deep inadequate aquifers of sub-soil water, presence of sand dunes, low extent irrigation were responsible for low level of agricultural development.

### **Very Low Level of Agricultural Development**

Barmer, Bikaner, Churu and Jaisalmer districts of Rajasthan had this category during the study period. These were agriculturally backward areas where inadequate irrigational facilities unfriendly topography as well as the adverse climatic factors especially desert area have low amount of rainfall, high temperature etc. were found

Owing to these reasons, most of the land was left unsown and had very low level of agricultural development.

### **Agricultural Infrastructure and Agricultural Development**

Agricultural infrastructure plays an important role in India where a larger percentage of poorer section of the society depends on agriculture for subsistence. The growth enhancing nature of the infrastructure demands a closer scrutiny of the relationship between the level of agricultural development and agricultural infrastructure from the regional perspectives. Infrastructure in agricultural sector is one of the major factors that could explain the regional balances and imbalances in the agricultural development. Agricultural infrastructure is the most essential input regarding the development of Indian agricultural, as one third population of the country depends on agricultural sector directly or indirectly. Agricultural sector contributes to the national gross domestic product is about 25 percent. This being the case, the objective of the present study is to analyze the role of infrastructure in agricultural development. This will facilitate the policy makers to take up some normative measures to address issues in infrastructural development.

The present study is focused on various elements of agricultural infrastructure and agricultural development (Table-2).

Table-2: Correlation between Infrastructure and Agricultural Development

Variables	1980-81	2019-20
	Rajasthan	Rajasthan
Irrigation Extent	0.75	0.80
Irrigation Intensity	0.54	0.69
Cropping Intensity	0.51	0.66
Percent Area Under HYV Seeds to TCA	0.67	0.63
Livestock Per Hectare of NSA	0.11	0.20
Percent of Agricultural Workers to Total Workers	0.29	0.31
Pumps Per Hectare	0.42	0.64
Tractors Per Hectare	0.61	0.58
Consumption of Fertilizer (Kg/Ha)	0.82	0.84
Percent of Scheduled Caste	0.34	0.32
Percent of Scheduled Tribes	0.13	0.14
Literacy Percent	0.17	0.25

Source: Directorate of Economics and statistics, jaipur

### **Irrigation**

Irrigation has three benefits first, it allows the cultivation of land where rainfall is insufficient for any crop growth. Second, it is an important supplement in regions where rainfall in the growing season is variable; and-third, it allows water to be stored in the wet season and used in the dry season-, thus allowing two crops to be obtained during the year. A controlled water supply allows much higher yields, and also ensures that fertilizers can be fully utilized; in dry-areas a low proportion of fertilizers that are applied are actually taken up by the plant's roots. Availability of perennial irrigation encourages the farmers to adopt more scientific techniques as well as intensive cultivation. The latter provides him to use the best quality of high yielding varieties of seeds at the right time and to reap the bigger margins of profit. Plants need certain amount of water at certain stages. Thus, irrigation has the direct impact an agricultural development. In the Rajasthan, correlation between both indicators of irrigation (irrigation extent and irrigation intensity) and agricultural development was quite significant at the both point of study time.

### **Cropping Intensity**

The intensity of cropping refers to raising a number of crops from the same field during one agricultural year. Thus, it is an indicator of the potentiality and performance of the land and can explain the level of agricultural development. Correlation between levels of agricultural development and cropping intensity was much positive during the study period.

### **Improved Seeds**

High yielding variety seeds played vital role in the progress of agriculture. They are considered as 'miracle seeds'. HYV seeds give better quality yielding than traditional seeds. The maturity time of crop is less. Multiple crops can be grown easily. Seeds are mostly flood and drought resistant. Problems of pests and diseases are less. Net agricultural income increases substantial. The efficacy of other agricultural inputs such as fertilizers, pesticides and irrigation is largely determined by the quality of the seed used. **Table-2** shows medium level of positive correlation between the percentage area under HYV crops and level of agricultural development. It suggests that use of HYV seeds is not only factor for agricultural development.

### **Livestock**

Driven by the structural changes in agriculture, the utility of livestock as source of 'draught power' has declined considerably due to mechanization of agricultural

operations and declining farm size. Use of dung manure is increasingly being replaced by chemical fertilizers. Correlation between livestock population and agricultural development is poorly positive. It shows that livestock population does not have much impact on agricultural development.

### **Agricultural Workers**

Agricultural workers include cultivators and agricultural laborers. The introduction of new and advanced technologies in the agricultural sector has changed the nature of labour demand. Correlation between percents of agricultural workers and agricultural development is not much significant, which indicates that the use of advance technologies and inputs have made the relationship between agricultural workers and agriculture weaker. It is important to note that the advance technology demands more of agricultural labors than the cultivators (**Table-2**).

### **Pumps Sets**

Pump sets includes both type of electric and diesel engines. These are used for and tube well irrigation. This type of irrigation" is much important in the area where canal irrigation is not possible. As pump sets: are an indicator of mechanization in agricultural and mechanization has impact on agricultural development. So it is supposed to have pump sets influence on agricultural development. **Table-2** show that the level of correlation between numbers of pump sets per hectare and agricultural development was moderately high.

### **Tractors**

Availability of adequate farm power is very crucial for timely farm operations, increasing land and labour efficiency, increasing production and productivity and reducing crop produce losses. Mechanization can also minimize the issues of scarcity of farm labour during peak agricultural seasons like sowing and harvesting. Tractor is an important element of mechanization. Today tractors are extensively used in agriculture. Various tasks of men and animals have been replaced by tractor. Tractors have significant role in agricultural development, so the analysis of its relationship with agricultural development is much important. The level of correlation between numbers of tractors per hectare and agricultural development was high and increased during the study period (**Table-2**).

### **Consumption of Fertilizers**

Soil fertility largely depends on its nutrient status: the amount and rates of nutrient supplies for plant growth. An adequate nutrient supply is an essential factor

in plant growth. Without an external input, the capacity of the soil to supply plants with nutrients is progressively reduced with every harvest; Fertilizers are necessary to replace the nutrients that have been removed from the soil. Chemical fertilizers are the immediate source of nutrients in soils. The level of correlation between use of fertilizers and agricultural development was much higher. It suggests that fertilizer have significant impact on agricultural development.

### **Scheduled Caste and Scheduled Tribe**

Rajasthan society is inter-crossed by a network of castes. Casteism is so much prevalent in Rajasthan village that it roots in mode of domestic and social life, cultural pattern and occupational characteristics of the people and so also it roots to agricultural development. The scheduled tribes live in remote areas of isolation. They are very much backwards even though they play an important role in agricultural activities. These people are employed as agricultural laborers and cultivators, the correlation between scheduled population and agricultural development is not significant (**Table-2**). Although it is positively correlated but not much affects the level of agricultural development because scheduled population is not the key factor responsible for agricultural development. It plays vital role in the structure of labour force which ultimately affects agricultural development.

### **Literacy Rate**

The literate cultivators can make best use of available resources improve agricultural condition of the area he cultivates and can give new directions for the future development of agricultural. Its importance lies in the fact that it has a significant impact on the adoption and the utilization of technology, which in turn, affect the allocation of resources and productivity. A well-trained and well-educated labour force is said to be in a better position to assess changing conditions and make necessary adjustments. The correlation between literacy rate and agricultural development is not much significant. However the role of literacy has to be verified through some other measures because it cannot be completely left aside as an unimportant variable for agricultural development.

### **Agricultural Development in Relation to Agricultural Infrastructure**

The parameters estimated from the multiple linear regressions between elicited districts level factor scores by principal component analysis as an independent explanatory variable and agricultural development as dependent variable have been presented in **Table-3**.

Table-3: Agricultural Development in Relation with Infrastructural Factors

Model	Un-standardized coefficients		Standardized Coefficients	t-value	Correlation	
	B	St. Error	B		Simple	Partial
Constant	77.294	2.086		37.158		
Factor I	3.142	2.142	.361	1.46	.316	.359
Factor II	1.284	2.169	.268	.59	.08	.011
Factor III	6.862	2.148	.481	3.20*	.446	.492
Factor IV	2.421	2.130	.469	1.13	.128	.182

Source: Computed, \* Significant at 1% level of significance

$$R^2 = .787, R\bar{2} = .744, D.W. = 1.285, F(4,28) = 2.868$$

It is clear from the data computed that agricultural development has positive and significant association with all the factors and significant at 1 percent level of significance with Factor-3. Partial correlation also shows the positive association of all the factors with agricultural development.

### Factor Analysis of Determinants of Agricultural Development in Rajasthan

This analysis is very important for several reasons, first there is no denying about the policy importance to determine agricultural development and their relationship with the overall development. If agriculture turns out to have significantly influenced the growth performance of Rajasthan, this may call more capital formation in agriculture. Second this study examines the inter linkages between agriculture and development performance of the economy. Here the agricultural development is termed as a dependent variable and four agricultural development indicators; reduced by factor analysis using principal component Analysis (P.C.A) and various with Kaiser Normalization as independent variables. Furthermore, we have ranked all the sampled districts. This study region on the basis of composite indices of agricultural development indicators. The factorial investigation facilitates the linkages and helps to select' the relevant variables for to construct the composite indices. The opposite indices will help in identification of the agricultural sensitive that need to be concentrated to upgrade the level of developments. Here we have made an attempt to rank the 32 districts of Rajasthan on the basis of composite index based agricultural development indicators. We have used K.M.O. and Bartlett's test to see the strength of the relationship among

variables. Large values for K.M.O measure indicate that a factor analysis is good. Here the measure of sampling adequacy is 0.682, indicating that the value is -large enough to proceed factor analysis for the data. Bartletfs test of sphericity is another indicator of the strength for the data relationship among the variables that the population correlation matrix is uncorrelated. Here the level of significance is .001. Factor scores are extracted for all the districts of the study area. It depicts the underlying sectoral dimensions of development and we have obtained the index of overall agricultural development with the help of four factor scores (Table-4).

Table-4: Rotated Component Matrix

S. No.	Variable	Factor-1	Factor-2	Factor-3	Factor-4	Communality
1.	IE	.842 (.241)	.168 (.632)	.901 (.632)	.201 (.816)	.869
2.	II	.878 (.219)	.291 (.30)	.235 (.188)	.484 (.614)	.811
3.	CI	.749 (.201)	.208 (.081)	.324(1.24)	.618 (.621)	.841
4.	IS	.799 (.289)	.854 (.56)	.018 (.192)	.241 (.154)	.761
5	LS	.614' (.318)	.477(1.36)	.204 (.161)	.869 (.169)	.854
6.	AW	.714(1.282)	.614(1.84)	0.41 (0.81)	.581 (.241)	.742
7.	PS	.928(1.04)	.856 (.266)	.458(1.29)	.584 (.331)	.882
8.	NT	.818(0.982)	.621 (.418)	.298(1.28)	.649 (.342)	.712
9.	CF	.791 (.384)	.624(1.281)	.348 (.161)	.61 8 (.338)	.541
10.	SC	.641 (.184)	.613(1.649)	.394 (.246)	.284 (.681)	.862
11.	ST	.518 (.214)	.571 (1.448)	.928 (.462)	.181 (.694)	.852
12	LR	.792(1.41)	.109 (.861)	.667(.51 9)	.681 (.819)	.899
13	PL	.624(2.22)	.208 (.621)	.248 (.618)	.246 (.419)	.729
14	LP	.282 (.268)	.416(1.28)	.692 (2.84)	.469(1.81)	.684
15	CC	.419(1.892)	.621 (2.84)	.719 (.86)	.411 (.84)	.719
16	AO	.284 (.681)	.841 (2.28)	.6180286)	.211 (.618)	.849
Eigen Values		4.864	3.298	2.282	3.118	
% of Variance		26.284	22.81	16.84	14.26	

Note: (a) Extraction Method: P.C.A., Rotation Method: Varimax with Kaiser Normalion. (b) Rotation Converged in 5 iterations. (c) Figures in Brackets are the factor score coefficients.

The factors solution reveals that the first factor (F-1) factor includes productivity of land, irrigation extent, irrigation intensity, cropping intensity,

improved or H.Y.V. seeds and use of livestock. All these variables are found to be positive and significantly contributing to the agricultural development. The second factor (F-2) includes labour productivity, percent of agricultural workers and literacy rate. All these variables are found to be positive and significantly affecting the agricultural development. The third factor (F-3) includes the percent area under cash crops, uses of pumps and oil engines, use of tractors, consumptions of fertilizers etc. All these variables led positive impact on the agricultural development. The Fourth factor (F-4) includes per capita agricultural output, S.C. population and S.T. Population. All of these factors are positively associated with the agricultural development of the study region.

### Regression Model

Here we have also made an attempt of simple linear regression to analyze the cause-and-effect relationship between the agricultural development and the selected explanatory variables. Following model equation has been adopted.

Whereas:

$Y_i$	=	Agricultural development
	=	Constant
$X_i$	=	Independent Variable (X1 to X16)
$X_1$	=	Irrigation Extent (IE)
$X_2$	=	Irrigation Intensity (II)
$X_3$	=	Cropping Intensity (CI)
$X_4$	=	Percent Area under Improved Seeds (IS)
$X_5$	=	Number of Livestock per Hectare of NSA (LS)
$X_6$	=	Percent of Agricultural Workers to Total Workers (AW)
$X_7$	=	Number of Pump Sets per Hectare (PS)
$X_8$	=	Number of Tractors per Hectare (NT)
$X_9$	=	Consumption of Fertilizer (CF)
$X_{10}$	=	Percents of Scheduled Caste Population (SC)
$X_{11}$	=	Percent of Scheduled Tribe Population (ST)
$X_{12}$	=	Literacy Rate (LR)
$X_{13}$	=	Productivity of Land (PL)

- X<sub>14</sub> = Labour Productivity (LP)
- X<sub>15</sub> = Percent Area under Cash Crops (CC)
- X<sub>16</sub> = Per Capita Agricultural Output (AO).

Table-5: Results of the Regression Model

Variables	B	t-value	R <sup>2</sup>	R <sup>2</sup>	F-value	P-value	R <sup>2</sup>	R <sup>2</sup>
X <sub>1</sub>	.286	1.28	0.28	.24	16.782	0.00016	0.92	0.902
X <sub>2</sub>	.246	1.26	0.24	.22				
X <sub>3</sub>	.461	0.96	0.46	.40				
X <sub>4</sub>	.491	0.821	0.49	.41				
X <sub>5</sub>	.281	0.684	0.28	.20				
X <sub>6</sub>	.168	1.628	0.16	.11				
X <sub>7</sub>	.668	2.889*	0.66	.582				
X <sub>8</sub>	.496	1.982**	0.49	.412				
X <sub>9</sub>	.746	3.866*	0.74	.704				
X <sub>10</sub>	.118	1.008	0.118	.098				
X <sub>11</sub>	.126	0.182	0.12	.11				
X <sub>12</sub>	.416	1.991**	0.41	.39				
X <sub>13</sub>	.681	2.682*	0.68	.602				
X <sub>14</sub>	.091	0.012	0.09	.08				
X <sub>15</sub>	.482	1.962**	0.48	.384				
X <sub>16</sub>	.431	.621*	0.62	.541				

Source: computed by Author

\* Significant at 1% level of significance

\*\* Significant at 5% level of significance

Here the null hypothesis is H<sub>0</sub> : B = 0 means explanatory variables do not led any significant effect on the agricultural development. Here the B- value obtained

for the explanatory variables are 0.28, 0.24, 0.46, 0.49, 0.28, 0.16, 0.66, 0.49, 0.74, 0.11, 0.12, 0.41, 0.68, 0.09, 0.48 and 0.62. The Joint R is 0.92 which shows that all the explanatory variables bring 92 percent variations in agricultural development. Our model is found to be best fitted here because the value of R<sup>2</sup> and R is quite high. Our null hypothesis is rejected as calculated p-value is less than 5 percent or 1 percent therefore it can be concluded that explanatory variables are significant by affecting the agricultural development of the study region.

### **Conclusion**

The status of agricultural development in Rajasthan is assessed on the basis of various sixteen indicators like extent of irrigation, irrigation intensity, cropping intensity, use of improved seeds, fertilizer, mechanization, population aspects, productivity etc. This assessment has shown considerable disparity in agricultural development in the study region. Disparity in agricultural development in Rajasthan across different districts is a matter of deep concern. The regional variation in agricultural development across various districts of the study region may be attributed to differential resource endowment in terms of soil fertility, land utilization pattern, average annual rainfall, irrigation, infrastructure facilities and also socio-cultural and economic conditions of farmers. The study has shown that agricultural development is higher in by eastern and northern parts of Rajasthan also had satisfactory level of agricultural development. In these parts farming is generally carried out with commercial attitude and by adopting advance farm technology, with irrigational facilities such as canal irrigation, well irrigation and tube well irrigation. Thereby large areas have irrigational facilities. This high development is due to high fertility of soils, intensive cultivation and assured water supply. These were the areas that were much influenced to green and technical revolution, resulted high level of agricultural development whereas the western desert part followed by central hilly part of Rajasthan had low level of agricultural development. The reasons for agricultural backwardness of these parts are not difficult to understand. In these parts, the agricultural sector is largely depending on rainfall which has been erratic and it is supplemented by ground water not adequate. Sandy or coarse soil and less use of new farm technology and less use of fertilizers are contributing factors for low level of agricultural development. Agriculture is diverse, complex, under-invested, risky and vulnerable in these parts. The region also lacks of alternate sources of water for irrigation. Further harsh and worsening bio-physical conditions exacerbate the region's vulnerability. All these factors

are responsible for the under growth and poor performance of agriculture there. In future these parts may attain faster development when water made available.

### **References**

- Ahmad, A. and Shamim, S.K. (2000): 'Regional Imbalances of Agricultural Productivity: A study Of Upper Ganga- Yamuna Doab.' *India Journal of Regional Science*, Vol. 32 pp. 109-120.
- Bhatia, S.S. (1962): 'A New Measure of Agricultural Efficiency in Uttar Pradesh, India,' *Economic Geography*, Vol. 43 pp. 244\_60.
- Kothari, Sadhana and Kohli, Anju (2003): 'Inter District Variation Agricultural Productivity in Rajasthan' *Journal Annals of NAGI*, Vol. 23 No.2.
- Taufique, M., Mumtaz, Z. and Munir, A. (2001): 'Spatial Analysis of Agricultural Productivity in Western Uttar Pradesh', *Geographical Review of India*, Vol. 63, pp. 129-140.
- Vishwakarma, (2003): 'Relationship between Structural Determinants and Agricultural Productivity in the Betul-Chhindwara Plateau Madhya Pradesh,' *Geographical Review of India* Vol. 65 pp. 151-161.

Dr. Pramila Sharma  
Department of Geography  
Govt. PG College, Thalawar  
(Rajasthan)



## **ASSESSMENT OF LANDUSE AND LANDCOVER CHANGES AND SPECTRAL INDICES IN VARANASI CITY, UTTAR PRADESH**

Nazreen Khanam, Lubna Siddiqui, Dr. Masood Ahsan Siddiqui,  
Dr. Braj Raj Kumar Sinha and Dr. Intikhab Ahmad

### **Abstract**

The study on Varanasi City's urbanization trends from 1992 to 2019 reveals significant transformations in its landscape, profoundly impacting environmental sustainability. Rapid urban growth, driven by economic factors and population dynamics, has reshaped land use and land cover (LULC), leading to extensive changes in urban morphology and environmental conditions. Built-up areas expanded dramatically from 20.024 km<sup>2</sup> to 138.033 km<sup>2</sup>, indicating substantial urban sprawl at the expense of natural landscapes. Conversely, vegetation cover decreased sharply from 78.623 km<sup>2</sup> to 43.972 km<sup>2</sup>, highlighting the loss of green spaces due to infrastructure development. Spectral indices such as the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) were employed to assess these changes. NDVI values exhibited a decline from 0.2155 to 0.1340 over the study period, indicating reduced vegetation density amid urban expansion. Meanwhile, NDWI showed slight fluctuations, suggesting changes in water presence, while NDBI values remained stable, reflecting consistent levels of built-up areas. The study utilized Landsat satellite data and Geographic Information System (GIS) techniques to map and analyze spatiotemporal variations in LULC and spectral indices. This approach facilitated a comprehensive understanding of urbanization's impacts on Varanasi's environment, emphasizing the emergence of urban heat islands (UHIs) and other environmental challenges. UHIs, characterized by elevated temperatures in urban areas compared to surrounding rural areas, underscore the need for sustainable urban planning strategies. Policy interventions are crucial to mitigate these impacts and promote sustainable development in Varanasi City. Initiatives focusing on green infrastructure, land use planning, and environmental conservation are essential to balance urban growth with ecological preservation. Continued monitoring and analysis using remote sensing technologies are recommended to track future trends and support adaptive strategies in urban development and environmental management. Overall, the study provides valuable

insights into the dynamics of urbanization and its environmental consequences, guiding informed decision-making for the city's future sustainability.

## **Introduction**

Urbanization, characterized by unorganized expansion, immigration, and population growth, significantly impacts environmental sustainability. It alters landscapes through land use and land cover changes, which affect food security, climate, hydrology, and biodiversity (F. Huang et al., 2020; Nimish et al., 2020; Yan, 2022). The shift from natural to urban areas, driven by economic growth, can degrade environments and disrupt ecosystems (Chen, 2022; X. H. Huang Lu; Sun, Ge; Yang, Zong-Liang; Li, Wenhong; Chen, Dongxu, 2022). Urban development often leads to urban heat islands, where increased temperatures due to concrete and asphalt replace vegetation and soil, exacerbating environmental impacts (Ahmed, 2013). These global issues are particularly pronounced in regions like Africa, where population growth drives dynamic land-use/land-cover changes (Adeyeri, 2017). In Ethiopia's highlands, agricultural expansion has replaced natural forests and grasslands, impacting soil quality and ecosystem stability (Arsiso, 2018; Hassen, 2017). The Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are critical in studying these changes, reflecting vegetation health and water presence across landscapes (Alexander, 2020; Govil, 2019; Guha, 2017). Varanasi exemplifies rapid urbanization amid environmental challenges, necessitating deeper exploration of spectral index relationships in urban settings. Since the late Pleistocene, human activities have significantly transformed the Earth's surface through industrialization and urbanization (Naikoo, 2020; Parveen et al., 2021).

Urbanization converts natural landscapes into built environments, altering land surface energy processes and biophysical environments (Fu & Weng, 2016). Over half of the world's population resides in cities, projected to reach 68% by 2050, intensifying localized pressures on urban areas (Abd-Elmabod et al., 2022). Studies in global cities like New York City and Tokyo reveal that built-up areas elevate environmental temperatures, while vegetation mitigates them through evapotranspiration (Khare et al., 2021; Laosuwan et al., 2017). High population density and limited green spaces exacerbate heat in cities like Dhaka and Mumbai, contrasting with findings in Indian states where reduced vegetation correlates with higher temperatures (Kumar et al., 2020; Sinha et al., 2020). The Thematic Mapper (TM) data from Landsat 5 enables detailed environmental studies, despite limitations in thermal band applications for emissivity determination (Dwivedi &

Rao, 1992). Satellite remote sensing, evolving since the 1970s, facilitates efficient monitoring and mapping of land use and cover changes, vital for understanding environmental dynamics (Wulder, 2016). This study employs GIS techniques to analyze temporal and spatial variations in land use/land cover and spectral indices in Varanasi, addressing gaps in quantifying their administrative impacts.

### **Study Region**

The study area, Varanasi City, situated in the eastern region of Uttar Pradesh, India, holds significant historical and geographical importance. Located on the left crescent-shaped bank of the Ganges River within the Ganges valley, Varanasi serves as the administrative center of Varanasi district and is part of the "Varanasi Urban Agglomeration," encompassing seven urban sub-units. Its geographical coordinates lie between latitudes 25° 14'N and 25° 23.5'N, and longitudes 82° 56'E and 83° 03'E, placing it in North India's fertile Indo-Gangetic Plains. Varanasi experiences distinct seasonal variations - rainy, winter, and summer - influenced predominantly by the southwest monsoon from mid-June to September, which contributes substantially to its annual rainfall of about 1009 mm. The city's climate features daily maximum temperatures ranging from 32°C to 34°C during summers and minimum temperatures around 26°C throughout the year. This climatic variability, coupled with rapid urban growth over recent decades across its approximately 82 square kilometers, makes Varanasi an ideal location for studying phenomena such as Urban Heat Islands (UHIs). Beyond its geographical and climatic characteristics, Varanasi is renowned globally as one of the oldest continuously inhabited cities, with a history spanning more than 3,000 years. Originally known as Kashi, it evolved from a center of trade and commerce into a hub of learning, culture, and religious significance. The city's rich heritage includes its association with Buddhism, where it is revered as the place of Buddha's first sermon. Over the centuries, Varanasi has flourished under the rule of various empires, leaving behind a legacy of silk weaving, art, architecture, and profound spiritual importance. Varanasi City's unique blend of historical heritage, geographical location, and urban development dynamics provides a compelling backdrop for investigating the interplay between land use, land cover dynamics, and environmental changes, particularly in the context of contemporary urban challenges like Urban Heat Islands.

### **Objectives**

- (1) Analyze the spatiotemporal changes in land use and land cover (LULC) and spectral indices in Varanasi City from 1992 to 2019.

- (2) To investigate the spatiotemporal changes in Spectral Indices and Environmental
- (3) Transformation in Varanasi City using multi-temporal satellite data from 1992 to 2019.

### **Database and Methodology**

The study analyzed multi-temporal Landsat 5 TM and Landsat 8 OLI/TIRS data spanning from 1992 to 2019 to assess land use and land cover (LULC) changes in Varanasi, Uttar Pradesh. Satellite images were sourced from the USGS Earth Explorer, and the area of interest (AOI) was delineated using ERDAS Imagine software based on the Survey of India Toposheet. Geometric and radiometric corrections were applied to ensure data accuracy. Various spectral indices were computed using ERDAS Imagine and ArcGIS software: the Normalized Differential Built-up Index (NDBI) for urban areas, the Normalized Differential Bareness Index (NDBaI) for bare land, the Normalized Difference Vegetation Index (NDVI) for vegetation density, the Enhanced Vegetation Index (EVI) for enhanced vegetation monitoring, and the Normalized Difference Water Index (NDWI) for water bodies. Temporal changes in LULC and spectral indices were analyzed to identify trends over the study period. Spatial distribution and variations were mapped to understand the impacts of urbanization. The study also explored the correlation between LULC changes and Urban Heat Islands (UHIs), providing insights for future urban and environmental planning. Software tools included ERDAS Imagine for AOI extraction and spectral index calculations, ArcGIS for spatial analysis, and SPSS Studio for statistical analysis and correlation determination. This comprehensive approach provided valuable insights into LULC dynamics and their implications for Varanasi's urban development.

### **Equations for Spectral Indices**

#### **Calculation of Normalized Difference vegetation index (NDVI)**

The Normalized difference vegetation index (NDVI) is calculated using the formula mention below (Chander and Markham, 2003). The NDVI value varies from -1 to 1. Higher the value of it reflects high Near Infrared (NIR), means dense greenery (Zhang et al., 2016).

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} \dots\dots\dots (1)$$

Where NIR is Band 4 for Landsat 5TM and Band 5 for Landsat 8 OLI and Red is Band 3 for Landsat 5TM and Band 4 for Landsat 8 OLI.

**Normalize Difference Built-up Index (NDBI)**

The Normalized Difference Built-up Index (NDBI) was used to enhance the built-up features of the earth's surface. It is an automated mapping technique for urban built-up areas that utilizes the ratioing technique similar to NDVI. According to Zha et al. (2003), the reflectivity of buildings and urban areas is more concentrated in the middle-infrared (MIR) band compared to the near-infrared (NIR) band, making it possible to calculate the built-up land using the equation,

$$NDBI = (SWIR - NIR) / (SWIR + NIR) \dots\dots\dots (2)$$

**Normalize Difference Water Index (NDWI)**

The Normalized Difference Water Index (NDWI) is a spectral index used to detect water bodies in remote sensing imagery. It enhances water features by comparing reflectance values in the green and near-infrared bands. NDWI has been widely effective in identifying water bodies but may overestimate in areas with low reflectance, like turbid water, where visible spectrum reflectance is high but NIR reflects little or none.

$$NDWI = (NIR - SWIR) / (NIR + SWIR) \dots\dots\dots (3)$$

**Results and Discussion**

**Spatiotemporal Variations in Land Use/Land Cover (LU/LC) of Varanasi City**

The study investigates the spatiotemporal changes in Land Use and Land Cover (LULC) in Varanasi City from 1992 to 2019 during the Pre-Monsoon season. **Table-1** and **Fig. 1** illustrate the area (in Km<sup>2</sup>) and percentage changes of various LULC classes over the years.

Table-1: Landuse/Landcover for Pre-Monsoon Season in Varanasi City LULC Class

Landuse/Landcover	1992	2019
	Area (Km <sup>2</sup> )	Area (Km <sup>2</sup> )
Waterbody	19.967	22.957
Vegetation	78.623	43.972
Agricultural Land	158.758	108.749
Built-Ups	20.024	138.033
Open/Barren Land	44.466	19.059
Sandbar	41.34	29.354

Source: Authors

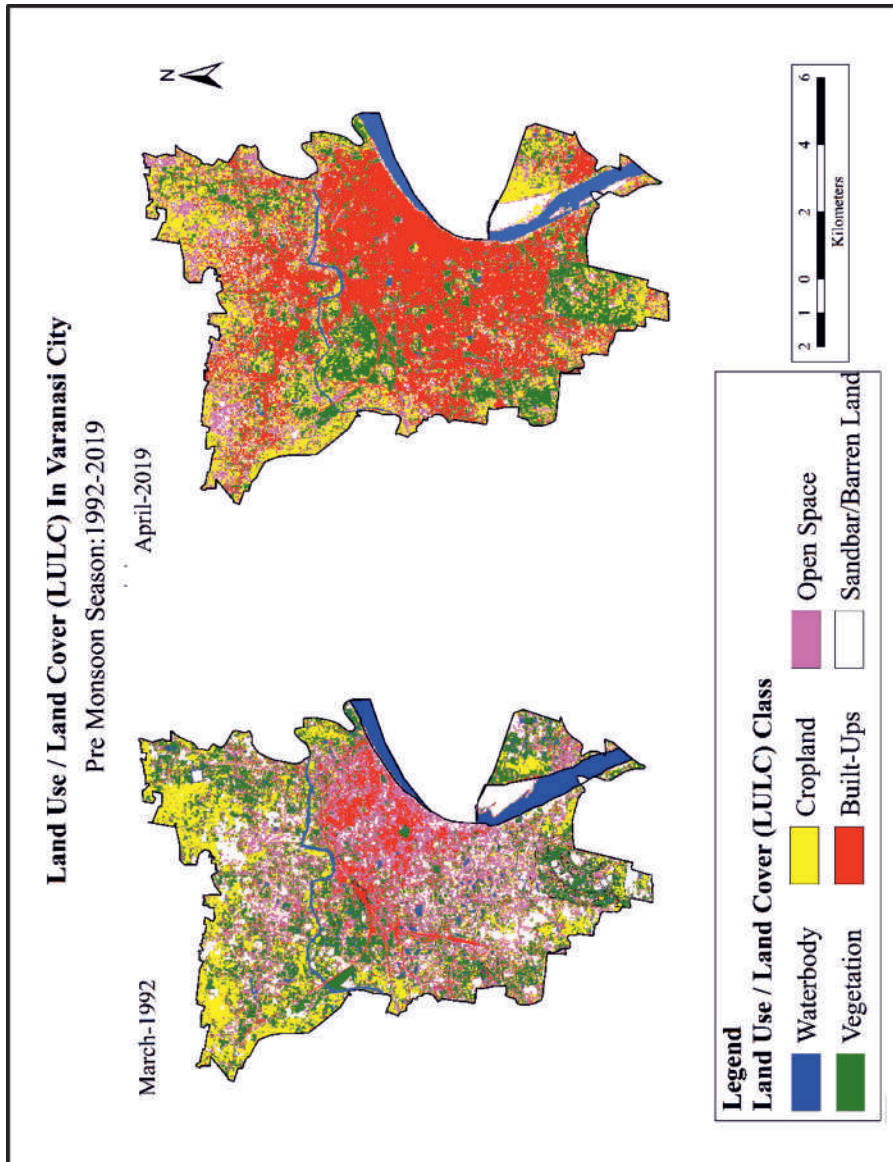


Fig. 1

The Waterbody class exhibited a slight increase from 19.967 Km<sup>2</sup> in 1992 to 22.957 Km<sup>2</sup> in 2019. Conversely, the Vegetation class decreased from 78.623 Km<sup>2</sup> in 1992 to 43.972 Km<sup>2</sup> in 2019 before a slight recovery. Agricultural Land showed an overall increase, peaking in 2010 before a decline in 2019. The Built-Ups class experienced substantial growth, expanding from 20.024 Km<sup>2</sup> in 1992 to 138.033 Km<sup>2</sup> in 2019, marking a significant urbanization trend. Open/Barren Land decreased initially but saw a minor increase in later years, while Sandbars decreased initially but notably increased by 2019. These changes highlight significant shifts in urbanization, agricultural practices, and environmental dynamics within Varanasi City over the past three decades. The increase in Built-Ups underscores ongoing urban expansion, impacting environmental sustainability and natural resource management.

### Land Use/Land Cover (Classification and Accuracy Assessment)

The LU/LC classification employed K-means clustering for mapping Varanasi City across multiple years. **Tables-2** detail classification results for Pre-Monsoon and Post Monsoon seasons, demonstrating high classification accuracy across all years with kappa coefficients ranging from 83% to 89%. This indicates robust agreement between classified maps and ground truth data, essential for reliable spatial analyses and environmental monitoring.

Table-2: LU/LC Accuracy assessment of classified images for Pre-Monsoon Season

LU/LC Class	1992 User's Accuracy (%)	1992 Producer's Accuracy (%)	2019 User's Accuracy (%)	2019 Producer's Accuracy (%)
Waterbodies	93	87	92	100
Vegetation Cover	85	93	90	76
Cropland	96	94	92	92
Built-Ups	83	83	95	99
Open Space/ Fallow Land	86	86	75	72
Sandbars	97	92	85	92
Overall Accuracy	92	91		
Kappa Coefficient	89	87		

Source: Authors

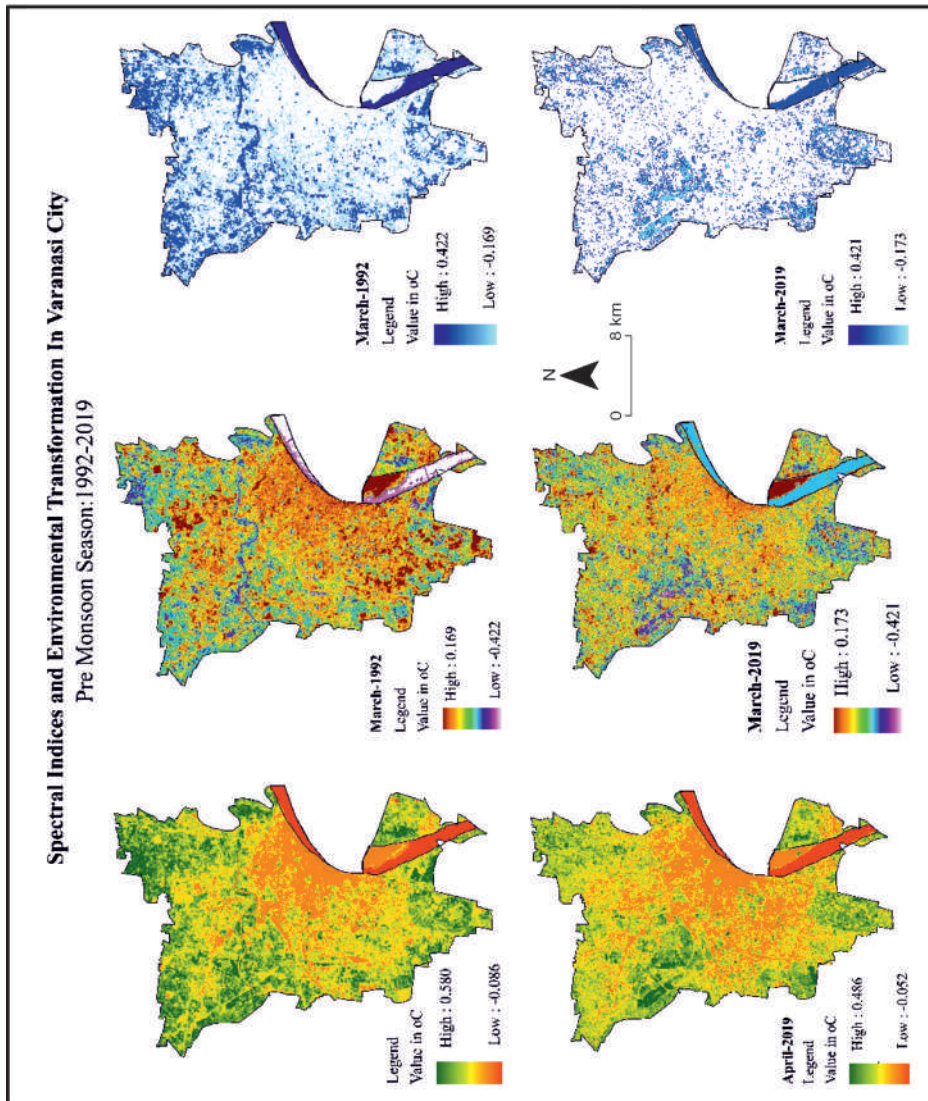


Fig. 2

The accuracy assessment confirmed consistent high accuracy levels (>80%) across all LU/LC classes, ensuring the reliability of the classified images for further research and policy formulation. The assessment underscores the importance of accurate land use mapping in understanding urban growth dynamics and environmental changes in Varanasi City.

### Spatiotemporal Variations of Spectral Indices in Varanasi City

#### Statistical Description of Spectral Indices for Pre-Monsoon Season: 1992-2019

**Table-3** provides statistical summaries of NDVI, NDWI, and NDBI indices across Varanasi City from 1992 to 2019. NDVI values decreased from a mean of 0.2155 in 1992 to 0.1340 in 2019, indicating declining vegetation density. Conversely, NDWI values showed a slight increase over the same period, while NDBI values remained relatively stable (Fig. 2).

Table-3: Statistical Description (Minimum, Maximum, Mean and Standard Deviation) of Spectral Indices for Pre-Monsoon Season in Varanasi City: 1992-2019

Year	Indices	NDVI	NDWI	NDBI
1992	Min	-0.0858	-0.1695	-0.4223
	Max	0.5799	0.4223	0.1695
	Mean	0.2155	0.0439	-0.0439
	Std dev.	0.0913	0.0869	0.0869
2019	Min	-0.0518	-0.1727	-0.4214
	Max	0.4862	0.4214	0.1727
	Mean	0.1340	0.0144	-0.0144
	Std dev.	0.0619	0.0392	0.0392

These trends highlighting the evolving environmental conditions and land use patterns in Varanasi City. These spectral indices provide critical insights into vegetation health, water content, and urban expansion dynamics, essential for sustainable urban planning and environmental management.

### Conclusion

The research into Varanasi City's land use and spectral indices spanning 1992 to 2019 reveals pronounced urbanization trends. Urban areas expanded significantly from 20.024 km<sup>2</sup> to 138.033 km<sup>2</sup>, contrasting sharply with a notable decline in vegetation cover from 78.623 km<sup>2</sup> to 43.972 km<sup>2</sup>, highlighting the

extensive impacts of urban growth. Analysis of spectral indices indicates a decrease in NDVI from 0.2155 to 0.1340, signaling reduced vegetation density, while NDWI showed a slight increase, suggesting changes in water presence. NDBI values remained stable, indicating consistent levels of built-up areas. These findings underscore the challenges posed by urban development, including urban heat islands and environmental degradation. Effective urban planning strategies are essential to mitigate these impacts and promote sustainable development in Varanasi. Policy interventions should prioritize green infrastructure and strategic land use planning to balance urban expansion with ecological conservation efforts. The study's utilization of spectral indices such as NDVI and NDWI offers critical insights into environmental health and water resource management, supporting informed decision-making. Continued monitoring and analysis are crucial for assessing future trends and implementing adaptive strategies in urban development and environmental conservation efforts in Varanasi City.

## References

- Abd-Elmabod, S. K., Jiménez-González, M. A., Jordán, A., Zhang, Z., Mohamed, E. S., Hammam, A. A., Baroudy, A. A. E., Abdel-Fattah, M. K., Abdelfattah, M. A., & Jones, L. (2022). Past and future impacts of urbanisation on land surface temperature in Greater Cairo over a 45 year period. *The Egyptian Journal of Remote Sensing and Space Science*, 25(4), 961–974. <https://doi.org/10.1016/j.ejrs.2022.10.001>
- Adeyeri, O. E. ; A., A. A.; Ishola, K. A. (2017). Investigating surface urban heat island characteristics over Abuja, Nigeria: Relationship between land surface temperature and multiple vegetation indices. *Remote Sensing Applications: Society and Environment*, 7(NA), 57–68. <https://doi.org/10.1016/j.rsase.2017.06.005>
- Ahmed, B. and K., M. and Zhu, X. and Rahman, M. S. and Choi, K. (2013). Simulating land cover changes and their impacts on Land Surface Temperature in Dhaka. Bangladesh. *Remote Sens*, 5, 5969–5998.
- Alexander, C. (2020). Normalised difference spectral indices and urban land cover as indicators of land surface temperature (LST). *International Journal of Applied Earth Observation and Geoinformation*, 86(NA), 102013-NA. <https://doi.org/10.1016/j.jag.2019.102013>
- Arsiso, B. K. and T., G. M. and Stoffberg, G. H. and Tadesse, T. and Earth and Artis, Parts A. /B. /C. and A. ., D. and Carnahan, W. H. (2018). Influence of urbanization-driven land use/cover change on climate: The case of Addis Ababa, Ethiopia. *Physics and Chemistry*, 12, 313–329.
- Chen, H. H., Jinhui Jeanne; Dash, Sonam Sandeep; McBean, Edward; Wei, Yizhao; Li, Han. (2022). Assessing the impact of urbanization on urban evapotranspiration and its components using a novel four-source energy balance model. *Agricultural and Forest Meteorology*, 316(NA), 108853–108853. <https://doi.org/10.1016/j.agrformet.2022.108853>
- Dwivedi, R. S., & Rao, B. R. M. (1992). The selection of the best possible Landsat TM band combination for. *Int. J. Remote Sens*, 13(11), 2051-2058,.
- Fu, P., & Weng, Q. (2016). A time series analysis of urbanization induced land use and land cover change and its impact on land surface temperature with Landsat imagery. *Remote Sensing of Environment*, 175, 205–214. <https://doi.org/10.1016/j.rse.2015.12.040>

- Govil, H. G., Subhanil; Dey, Anindita; Gill, Neetu. (2019). Seasonal evaluation of downscaled land surface temperature: A case study in a humid tropical city. *Heliyon*, 5(6), e01923-NA. <https://doi.org/10.1016/j.heliyon.2019.e01923>
- Guha, S. and G., H. and Mukherjee, S. (2017). Dynamic analysis and ecological evaluation of urban heat islands in Raipur city, India. *J. Appl. Remote Sens*, 11(3), 1.
- Hassen, E. E. A., Mohamed. (2017). Land use/cover dynamics and its drivers in Gelda catchment, Lake Tana watershed, Ethiopia. *Environmental Systems Research*, 6(1), 1–13. <https://doi.org/10.1186/s40068-017-0081-x>
- Huang, F., Zhan, W., Wang, Z.-H., Voogt, J., Hu, L., Quan, J., Liu, C., Zhang, N., & Lai, J. (2020). Satellite identification of atmospheric-surface-subsurface urban heat islands under clear sky. *Remote Sensing of Environment*, 250, 112039. <https://doi.org/10.1016/j.rse.2020.112039>
- Huang, X. H., Lu, Sun, Ge; Yang, Zong-Liang; Li, Wenhong; Chen, Dongxu. (2022). Urbanization Aggravates Effects of Global Warming on Local Atmospheric Drying. *Geophysical Research Letters*, 49(2), NA-NA. <https://doi.org/10.1029/2021gl095709>
- Khare, V. R., Vajpai, A., & Gupta, D. (2021). A big picture of urban heat island mitigation strategies and recommendation for India. *Urban Climate*, 37, 100845. <https://doi.org/10.1016/j.uclim.2021.100845>
- Kumar, S., Shwetank, & Jain, K. (2020). A Multi-Temporal Landsat Data Analysis for Land-use/Land-cover Change in Haridwar Region using Remote Sensing Techniques. *Third International Conference on Computing and Network Communications (CoCoNet'19)*, 171, 1184–1193. <https://doi.org/10.1016/j.procs.2020.04.127>
- Laosuwan, T., Gomasathit, T., & Rotjanakusol, T. (2017). APPLICATION OF REMOTE SENSING FOR TEMPERATURE MONITORING: THE TECHNIQUE FOR LAND SURFACE TEMPERATURE ANALYSIS. *Journal of Ecological Engineering*, 18(3), 53–60. <https://doi.org/10.12911/22998993/69358>
- Naikoo, M. W. and R., M. and Ishtiaque, M. and Shahfahad. (2020). Analyses of land use land cover (LULC) change and builtup expansion in the suburb of a metropolitan city: Spatiotemporal analysis of Delhi NCR using landsat datasets. *Journal of Urban Management*, 9(3), 347–359. <https://doi.org/10.1016/j.jum.2020.05.004>
- Nimish, G., Sudeep, V. B., & Bharath, H. A. (2020). Impacts of Urban Land Use Land Cover Pattern on Land Surface Temperature. In *Lecture Notes in Civil Engineering* (pp. 37–49). Springer Singapore. [https://doi.org/10.1007/978-981-15-2545-2\\_5](https://doi.org/10.1007/978-981-15-2545-2_5)
- Parveen, N., Siddiqui, L., Sarif, M. N., Islam, M. S., Khanam, N., & Mohibul, S. (2021). Industries in Delhi: Air pollution versus respiratory morbidities. *Process Safety and Environmental Protection*, 152, 495–512. <https://doi.org/10.1016/j.psep.2021.06.027>
- Sinha, S., Santra, A., & Mitra, S. S. (2020). Semi-automated impervious feature extraction using built-up indices developed from space-borne optical and SAR remotely sensed sensors. *Advances in Space Research*, 66(6), 1372–1385. <https://doi.org/10.1016/j.asr.2020.05.040>
- Wulder, M. A. ; W., Joanne C. ; Loveland, Thomas R. ; Woodcock, Curtis E. ; Belward, Alan; Cohen, Warren B. ; Fosnight, Eugene A. ; Shaw, Jerad; Masek, Jeffrey G. ; Roy, David P. (2016). The global Landsat archive: Status, consolidation, and direction. *Remote Sensing of Environment*, 185(NA), 271–283. <https://doi.org/10.1016/j.rse.2015.11.032>
- Yan, Y. L., Tao; Wang, Ningcheng; Yao, Shenjun. (2022). Urban sprawl and fiscal stress: Evidence from urbanizing China. *Cities*, 126(NA), 103699–103699. <https://doi.org/10.1016/j.cities.2022.103699>

Zhang, F., Tiyyip, T., Kung, H., Johnson, V. C., Maimaitiyiming, M., Zhou, M., & Wang, J. (2016). Dynamics of land surface temperature (LST) in response to land use and land cover (LULC) changes in the Weigan and Kuqa river oasis, Xinjiang, China. *Arabian Journal of Geosciences*, 9(7). <https://doi.org/10.1007/s12517-016-2521-8>

--Dr. Nazreen Khanam  
PhD Geography  
Department of Geography  
Jamia Millia Islamia  
New Delhi

--Dr. Lubna Siddiqui  
Professor  
Department of Geography  
Jamia Millia Islamia  
New Delhi

--Dr. Masood Ahsan Siddiqui  
Professor  
Department of Geography  
Jamia Millia Islamia  
New Delhi

--Dr. Braj Raj Kumar Sinha  
Professor and Pro- Vice Chancellor  
Magadh University  
Bodh Gaya (Bihar)

--Dr. Intikhab Ahmad  
Assistant Professor  
Department of Geography  
Dyal Singh College  
University of Delhi  
New Delhi



## **SPATIAL ANALYSIS OF CRIME HOTSPOTS USING MORAN'S I AND GETIS-ORD GI\* STATISTICS IN JAIPUR CITY, INDIA**

Tanisha Sharma and Cheetar Mal Meena

### **Abstract**

Gender-based crimes refer to acts of violence or discrimination that are specifically targeted at individuals based on their gender. The frequency and diversity of illegal activities are increasing rapidly, causing organizations to create strong plans for preemptive actions. GIS and geospatial technologies play a crucial role in crime mapping and analysis, providing valuable insights into crime patterns, hotspots, and relationships between crime and the environment. These tools aid in resource allocation, patrol strategies, and decision-making for law enforcement agencies. They also help in identifying problem-oriented areas and enhancing the effectiveness and efficiency of policing processes. Overall, the studies underscore the importance of integrating advanced technologies, analytical techniques, and spatial analysis in crime prevention and control. Law enforcement agencies can proactively allocate resources, implement targeted interventions, and improve community safety by comprehending the spatial distribution of crime, identifying coldspots and hotspots, and predicting future criminal activity. This study utilizes the Getis-Ord  $G_i^*$  statistic to assess the spatial distribution of crime hotspots in Jaipur City. Additionally, the Moran's I approach is implemented to examine the clustering patterns of Rape and Kidnapping and Abduction crimes from 2015 to 2023. Information was collected from a total of 54 police stations located within the designated study area. These analytical tools provide a thorough comprehension of crime dynamics, assisting in the development of well-informed policies to address difficulties in Jaipur's municipal divisions, namely Greater Jaipur and Heritage Jaipur. Furthermore, the study emphasizes the importance of augmenting law enforcement training, enhancing community awareness programs, and utilizing technology to enhance crime prediction and prevention.

### **Introduction**

Crime has been a perplexing issue from the dawn of human civilisation, there isn't a society on the planet that isn't plagued by crime. Crime against women is

an alarming and pervasive problem that encompasses a wide range of violent, discriminatory, and abusive acts solely based on their gender (Doyel, 1999). It includes reprehensible acts such as domestic violence, sexual assault, rape, harassment, dowry-related violence, honor killings, female genital mutilation, forced marriages, human trafficking, and gender-based discrimination across various facets of life. These crimes have far-reaching detrimental effects on the lives of women, severely impacting their physical and mental well-being, as well as their overall quality of life. Moreover, they perpetuate gender inequality and reinforce damaging stereotypes, effectively curbing women's autonomy and limiting their opportunities for growth and success (Singh, 2010). Tahir (1996) emphasizes that while numerous studies have examined crimes against women, few scholars have attempted to explain the spatial analysis of these crimes, which is the primary focus of geographers. Tahir further explores and analyzes the geography of crime on three levels: the locations where offenses occur, the profiles of the offenders, and the roles of the police and media in their efforts to combat and highlight these issues, respectively. Instances of escalating cruelty against women are unfortunately prevalent worldwide (Singh, 2010).

Geographic Information System is utilized for capturing, preserving, querying, exploring, and visually representing geospatial information. Geospatial data, also called geographically referenced data, encompasses details about both the position and qualities of spatial features, such as roads, land areas, and vegetation, present on the Earth's surface (Chang, 2008). Mafumbabete et al. (2019) utilized geospatial technologies to determine crime densities and identify crime hotspots and clusters in rural Zimbabwe. Their study employed Moran's I and Getis-Ord statistical tools, revealing areas with concentrated crime activity. This information proved valuable for law enforcement agencies in deploying patrols and implementing measures to combat crime and safeguard lives and property. Eck et al. (2005) have suggested that a crucial aspect of a geographical database is its capacity to employ GIS in order to visually investigate the spatial patterns of crime hotspots and their connections to other spatial data layers. Spatial analysis methods, such as the closest neighbour analysis, can determine the presence of patterns, clusters, or diverse interactions. Advanced techniques, such as the quadratic kernel density and quadrature analysis, can provide insights into the spatial intensity of crime. By employing analytical techniques like closest neighbour analysis, kernel density estimations, and quadrature analysis, visual explorations can effectively identify and dismiss observable patterns.

## Objectives

- (1) The mapping of crime hotspots utilizing Getis-Ord  $G_i^*$  statistic and clustering pattern through Anselin Moran's I
- (2) Comprehending crime trends through Fuzzy Overlay over a nine-year historical period.

## Study Region

Jaipur, situated within the former jurisdiction of the Jaipur Development Authority, serves as the capital of Rajasthan and is renowned as India's pink city. Jaipur is located in a latitude of  $26^{\circ}55'$  north and a longitude of  $75^{\circ}49'$  east. The municipal boundary stretches from a latitude of  $26^{\circ}46'$  North to a latitude of  $27^{\circ}01'$  North, and from a longitude of  $75^{\circ}37'$  East to a longitude of  $76^{\circ}57'$  East. The Nahargarh hills lie to the north of the city, while the Jhalana hills are situated to the east. Both of these hills form a portion of the Aravalli hill range. The city of Jaipur exhibits a varied population composition, comprising both rural and urban areas. The urban sector has a population of around 6.63 million, slightly more than the rural sector, which has a population of 3.47 million compared to 3.15 million. In both locations, the number of males surpasses the number of females. Specifically, metropolitan Jaipur has a male population of 1.83 million and a female population of 1.65 million, while rural areas have 1.64 million males and 1.51 million girls. According to the 2001 census, the population of Jaipur was 5,251,071, with 2,768,203 males and 2,482,868 females. The Jaipur Municipal Corporation is subdivided into two entities: the Jaipur Municipal Corporation Heritage and the Jaipur Municipal Corporation Greater. The heritage area of Jaipur is divided into five zones: Amer (ward No. 1 to 4), Hawa Mahal (ward No. 5 to 30), Civil Lines (ward No. 31 to 54), Kishanpole (ward No. 55 to 75), and Adarsh Nagar (ward No. 75 to 100). Greater Jaipur is divided into five zones: Vidyadhar Nagar includes wards 1 to 42, while Jhotwara includes wards 43 to 64. Sanganer encompasses ward numbers 65 to 103, Bagru encompasses ward numbers 104 to 124, and Malviya Nagar encompasses ward numbers 125 to 150.

## Database and Methodology

The crime incidence data from Jaipur City was evaluated and processed using Arc GIS in order to identify areas with low crime rates (cold spots) and areas with high crime rates (hotspots). The methodology employed in this study entails the examination of a dataset encompassing data on various heinous crimes perpetrated

against women which includes Rape and kidnapping and abduction of women with intent to outrage her modesty. The dataset spans from 2015 to 2023 and comprises data from 54 police stations located in Jaipur City. The data was categorized according to the Greater and Heritage Jaipur regions, and distinct analyses were performed for each region. To effectively combat crimes against women, it is imperative that we have a clearly defined and resolute strategy. In order to achieve this goal, it is important to carry out a thorough analysis of historical and current data trends. The identification of hotspot clusters was accomplished by employing the Getis-Ord  $G_i^*$  procedure (Getis & Ord, 1992; Ord & Getis, 1995), utilizing ArcGIS Spatial Statistics tools along with a predetermined distance band. The  $G_i^*$  statistic assigns a Z-score to each feature, indicating how much it deviates from the spatial average. This helps pinpoint statistically significant clusters of high or low values. Positive Z-scores yield a higher Z-score for more intense clustering of high values, while negative Z-scores signify more intense clustering of low values (Peeters et al., 2015). The premises of spatial autocorrelation have been a fundamental component of geographical analysis for over two decades. The study incorporated Anselin Moran's I technique to understand the clustering pattern of these crimes. Moran's I is a statistical measure that can be used to determine if crime episodes are concentrated, spread out, or randomly distributed within a specific geographical region.

## **Result and Discussion**

### **Getis Ord $G_i^*$ based Crime Hotspot**

The forthcoming figures depict the results obtained from the application of Getis Ord  $G_i^*$  statistics. Subsequently, the analytical approach was enhanced by implementing Fuzzy overlay to obtain a thorough understanding of the combined crime data from a period of nine years, comprising different types of crimes. Fuzzy overlay is a widely employed technique in geographical analysis and GIS that facilitates the comprehension of patterns, trends, and correlations across various spatial information. Although it is not commonly employed for direct crime trend analysis, it can serve as a valuable asset within a broader crime study framework.

Kidnapping and Abduction - In 2015, the areas with the highest incidence of kidnapping and abduction incidents were primarily located in the northern portion of Amer in heritage Jaipur and the southern part of Sanganer in greater Jaipur. In 2016, this pattern continued, and a new area of intense activity appeared in the Jhotwara region of greater Jaipur.

In 2017, the popular locations in the historic city of Jaipur were still concentrated on the northern area of Amer, much like in previous years. Nevertheless, in the wider region of Jaipur, the primary area of intense activity relocated to Jhotwara, while minor areas of intense activity emerged in Bagru and Sanganer. In 2018, notable alterations occurred in Jaipur, particularly in the heritage areas of Kishanpole, Civil Lines, and Hawa Mahal. In the broader region of Jaipur, the noteworthy changes were limited to the southern half of Sanganer. In 2019, the hotspots relocated, becoming restricted to the northern area of Amer in the historical city of Jaipur and the southern area of Sanganer in the larger Jaipur region. In 2020, there was a notable change in the geographical distribution of hotspots in Jaipur. The northern area of Vidhyadhar Nagar, together with the southern regions of Sanganer and Bagru, emerged as new hotspots in larger Jaipur. Meanwhile, the northern part of Amer continued to be a hotspot in the heritage area of Jaipur. In 2021, the pattern was comparable to that of 2020. However, in 2022, the area of high activity in the historic city of Jaipur shifted to the northeast section near Hawa Mahal. Meanwhile, in the larger Jaipur area, the southern part of Sanganer continued to be a hotspot. This same trend persisted in both Greater Jaipur and Heritage Jaipur in 2023. After conducting a comprehensive analysis using fuzzy overlay techniques, it was determined that the main areas with a high concentration of kidnapping and abduction cases in heritage Jaipur were Civil Lines, Kishanpole, Hawa Mahal, and Adarsh Nagar. In greater Jaipur, the southern part of Sanganer consistently stood out as a hotspot for these crimes.

The likely reasons behind the kidnapping and abduction of women are complex, arising from a blend of socio-economic, cultural, and legal elements. Women are frequently undervalued and objectified in cultural norms, resulting in their exploitation and abduction for various reasons, such as forced marriage, human trafficking, and domestic servitude. In some cases, this is done with the intention of disregarding the family's honor, as women are seen as a symbol of respect for the family. The presence of societal stigma and the concern of facing retaliation frequently deter victims and their families from reporting these crimes. The absence of reporting impedes endeavors to tackle and counteract the problem, enabling it to endure and maybe escalate. However, this situation has gradually shifted over time. Most cases of kidnapping in Jaipur occur in the main city center, which is a heritage part of Jaipur that includes commercial areas, recreational spaces, and public facilities such as educational institutions, medical facilities, public utilities, and community centers. This makes it easier for offenders or perpetrators to kidnap

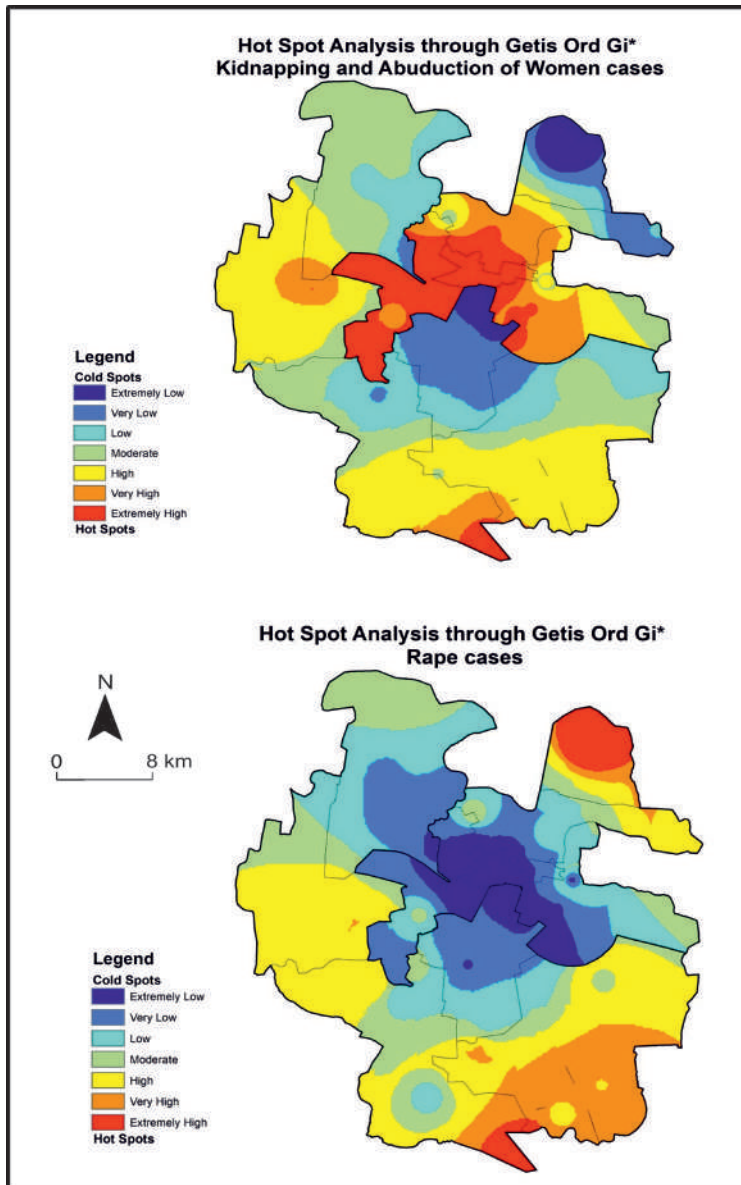


Fig. 1

individuals, as these areas are more vulnerable compared to the secure environment of one's home or local neighborhood. The hotspot zone in Greater Jaipur is located in the southern portion of Sanganer. This area is characterized by a combination of forested, industrial, and government reserved areas, which are currently unoccupied. These factors make this region particularly attractive to offenders involved in cases of kidnapping and abduction.

### **Rape**

The assessment of rape cases using hotspot mapping indicated a consistent and recurring trend. In 2015, the areas with the highest levels of activity were found in the northern region of Amer and the eastern region of Hawa Mahal in the historic city of Jaipur. In the larger Jaipur area, the hotspot was located in the southern part of Sanganer. In 2016, the hotspot area in the historic city of Jaipur was confined to the northern section of Amer, which is located on the outskirts. In the larger Jaipur area, the hotspots were found in the southern regions of Sanganer and Jhotwara. In 2017, the primary area of interest in the historic city of Jaipur was located in the northern region of Amer, while a new area of interest began to gain prominence in Hawa Mahal. The areas of south Sanganer and Malviya Nagar were identified as the hotspots in greater Jaipur. By 2018, the places in Jaipur that saw a high level of activity and popularity changed to the central region, specifically Civil Lines, Hawa Mahal, and Kishanpole. In the larger Jaipur area, Sanganer remained the most popular and active location. In 2019, there was a resurgence of popular areas in the northern region of Amer in the historical city of Jaipur, as well as in the southern region of Sanganer in the larger Jaipur area. This trend continued throughout 2020 and 2021. In 2022, several areas in Jaipur had a surge in popularity, particularly the northern section of Amer and the eastern half of Hawa Mahal, which are considered noteworthy. In addition, the southern areas of Sanganer and Bagru in greater Jaipur also became popular destinations. By 2023, the geographical distribution of hotspots in Amer, Jaipur had reverted to a pattern similar to that of 2015. Specifically, there were concentrated hotspots in the northern region of Amer, the eastern region of Hawa Mahal in the heritage city of Jaipur, and the southern region of Sanganer in the wider Jaipur area.

The examination of rape cases using the fuzzy overlay approach reveals that the northern half of Amer in heritage Jaipur constantly emerges as a hotspot. This is mostly owing to the area's physiography. The southern half of Sanganer, located on the outskirts of the town, is a prominent area in Greater Jaipur. Jaipur has experienced a high number of rape instances that can be linked to the distinctive

physical features of these specific areas. The geographical position of Amer, situated amidst the Aravalli range, offers an isolated setting that could potentially enable the occurrence of such criminal activities. Similarly, Sanganer, located on the outskirts of the city, is predominantly an industrial zone rather than a residential one. This makes it a prime location for such criminal activities due to its relative seclusion and lower population density. Moreover, the absence of sufficient security protocols and surveillance in these regions can exacerbate the occurrence of such criminal activities.

### **Anselin Moran's I based Crime Hotspot**

Moran's I is a statistical measure used to evaluate the presence of spatial autocorrelation. It determines whether a given pattern is clustered, scattered, or random, offering a comprehensive assessment of the geographical arrangement. A Moran's I value of 0 generally signifies a random pattern, indicating the absence of any noticeable spatial correlation in the crime data (Table-1). This suggests that the presence of criminal activity in one area is not influenced by the presence of criminal activity in surrounding areas. The crime data acquired in the current study has been categorized into two groups: greater Jaipur and heritage Jaipur. Within the Greater Jaipur division both the crime incidences demonstrates a scattered pattern of autocorrelation consistently throughout all the years. This indicates that these crimes are not concentrated in certain areas, but rather spread out randomly throughout the research area. This suggests an absence of geographical correlation, implying that the elements that influence the occurrence of crime are uniformly distributed. Instances of Kidnapping and Abduction and Rape have exhibited a concentrated distribution in certain years within the heritage Jaipur wards. A clustered pattern in Moran's I signifies spatial autocorrelation of crime episodes, indicating that places with high crime rates are in close proximity to other high-crime areas, while low-crime areas are near other low-crime areas. Kidnapping and abduction exhibited a concentrated distribution in the years 2015, 2022, and 2023 while Rape cases showed a clustered trend in 2016 and then consecutively for four years from 2020 to 2023. Heritage Jaipur attracts increased police scrutiny, leading to a higher number of reported crimes.

This is not necessarily due to an increase in actual criminal activity, but rather because more crimes are being identified and documented. Moreover, the heightened concentration in some years could also be impacted by socio-economic factors, shifts in population density, and fluctuations in community attentiveness. Improved public awareness campaigns and community policing initiatives could

also enhance the accuracy and documentation of crimes, therefore impacting the observed patterns.

Table-1: Clustering Pattern of Crime Cases through Anselin Moran's I Technique

Years	Z-Score	P-Value	Moran's Index	Pattern
Kidnapping and Abduction of Greater Jaipur				
2015	0.332058	0.739845	0.080330	Random
2016	-0.400227	0.688990	-0.173609	Random
2017	0.217361	0.827927	0.041129	Random
2018	0.456369	0.648125	0.123830	Random
2019	0.391532	0.695404	0.097691	Random
2020	-0.970222	0.331936	-0.370228	Random
2021	-0.109571	0.912750	-0.071572	Random
2022	-0.827679	0.407853	-0.324429	Random
2023	0.079169	0.936898	-0.007733	Random
Rape cases of Greater Jaipur				
2015	0.212092	0.832035	0.033903	Random
2016	-0.866062	0.386456	-0.337991	Random
2017	0.111793	0.910987	0.003260	Random
2018	-1.051344	0.293101	-0.399039	Random
2019	-0.402185	-0.175926	0.687548	Random
2020	0.393104	0.099048	0.694243	Random
2021	0.682432	0.494966	0.204025	Random
2022	-0.459840	-0.196100	0.645631	Random
2023	-0.632189	0.527264	-0.238669	Random
Kidnapping and Abduction cases of Heritage Jaipur				
2015	1.774290	0.076015	0.063720	Clustered
2016	0.459893	0.645593	-0.017315	Random
2017	0.876122	0.380964	0.008078	Random
2018	0.170620	0.864523	-0.035166	Random
2019	1.548742	0.121444	0.047552	Clustered

Contd...

2020	1.312385	0.189390	0.035576	Clustered
2021	1.616689	0.105945	0.053425	Clustered
2022	2.825065	0.004727	0.126099	Clustered
2023	3.177934	0.001483	0.146583	Clustered
Rape cases of Heritage Jaipur				
2015	0.390291	0.696322	-0.021519	Random
2016	1.199799	0.230218	0.27774	Clustered
2017	0.002227	0.998223	-0.045315	Random
2018	0.789612	0.429755	0.003347	Random
2019	0.875936	0.381065	0.008944	Random
2020	1.048293	0.294504	0.020091	Clustered
2021	1.179536	0.238185	0.026431	Clustered
2022	2.697363	0.006989	0.116465	Clustered
2023	1.842298	0.065432	0.067712	Clustered

Source: Authors

### Conclusion

The analysis of crimes against women reveals that these heinous acts do not always follow a predictable pattern. Unlike more common crimes such as dacoity (gang robbery) or theft, which tend to occur with some regularity, crimes against women often happen suddenly and unexpectedly. Rape offenses are heavily influenced by the specific circumstances and environment surrounding the perpetrator and victim. The mindset and motivations of the offender can be shaped by factors like alcohol abuse, mental health issues, or a sense of entitlement. Victims may be targeted due to their vulnerability, isolation, or perceived weakness. While kidnapping and abduction offences involves some degree of planning and forethought. The perpetrators may have a clear motive and target in mind before carrying out their criminal acts. The study also suggests that the physical geography and demographics of an area can shape crime patterns. Rape hotspots, for instance, tend to be located in areas with low population density or limited surveillance. Isolated or poorly lit locations, such as secluded parks, abandoned buildings, or deserted streets, provide opportunities for predators to target victims with reduced risk of detection or intervention, on the other hand, kidnapping and abduction hotspots are typically found in public spaces that are unfamiliar to the victim.

Crime patterns against women are also influenced by land use dynamics. Insult and assault cases often occur in areas with high concentrations of commercial, educational, or medical facilities, where women may be more vulnerable in public spaces like workplaces or during transportation. Over time, education has empowered many women to live independently from abusive in-laws and husbands, breaking down the barriers of patriarchal society and outdated stigmas. The increased reporting of sexual violence cases could be attributed to women feeling more comfortable coming forward, as the stigma surrounding these crimes has been reduced. Law enforcement agencies are working to improve reporting mechanisms and increase awareness among females through various initiatives and drives. Authorities have also taken steps to establish women-led police stations (mahila thanas) in different parts of the city, ensuring that victims can file complaints without facing any issues. In conclusion, while some crimes against women follow a more predictable pattern based on the offender's motives and the circumstances surrounding the crime, many serious offenses occur suddenly and unexpectedly. Understanding the complex interplay of individual, social, and environmental factors is crucial for developing effective crime prevention strategies and ensuring the safety and well-being of women in society.

## References

- Andresen, M. A. (2014). *The science of crime measurement: Issues for spatially-referenced crime data*. Routledge.
- Anselin, L., Cohen, J., Cook, D., Gorr, W., & Tita, G. (2000). Spatial analyses of crime. *Criminal justice*, 4(2), 213-262.
- Chainey, S., Tompson, L. and Uhlig, S., 2008. The utility of hotspot mapping for predicting spatial patterns of crime. *Security journal*, 21, pp.4-28.
- Chang, K.T., 2008. *Introduction to geographic information systems (Vol. 4)*. Boston: Mcgraw-hill.
- Eck, J., Chainey, S., Cameron, J., & Wilson, R. (2005). *Mapping crime: Understanding hotspots*.
- Getis, A. and Ord, J.K., 1992. The analysis of spatial association by use of distance statistics. *Geographical analysis*, 24(3), pp.189-206.
- Gill, P. (2013). Organised crime. In *Routledge Companion to Intelligence Studies* (pp. 313-320). Routledge.
- Gupta, R., 2020. Behavioural mapping of crime hotspots in Delhi: A spatial analysis. *Transactions*, 42(2), p.283.
- Hajela, G., Chawla, M., & Rasool, A. (2020). A clustering based hotspot identification approach for crime prediction. *Procedia Computer Science*, 167, 1462-1470.
- Kaur, B., Ahuja, L., & Kumar, V. (2020). Modeling the factors affecting crime against women: Using ISM technique. In *Advances in Computing and Intelligent Systems: Proceedings of ICACM 2019* (pp. 469-478). Springer Singapore.

- Kedia, P. (2016). Crime mapping and analysis using GIS. *International Institute of Information Technology*, 1(1), 1-15.
- Kumar, M. V., & Chandrasekar, C. (2011). Spatial clustering simulation on analysis of spatial-temporal crime hotspot for predicting crime activities. *International Journal of Computer Applications*, 35(3), 36-43.
- Lersch, K. M., & Hart, T. C. (2014). Environmental justice, lead, and crime: Exploring the spatial distribution and impact of industrial facilities in Hillsborough County, Florida. *Sociological Spectrum*, 34(1), 1-21.
- Mafumbabete, C., Chivhenge, E., Museva, T., Zingi, G.K. and Ndongwe, M.R., 2019. Mapping the spatial variations in crime in rural Zimbabwe using geographic information systems. *Cogent Social Sciences*, 5(1), p.1661606.
- Manepalli, U.R., Bham, G.H. and Kandada, S., 2011, September. Evaluation of hotspots identification using kernel density estimation (K) and Getis-Ord ( $G_i^*$ ) on I-630. In 3rd International Conference on Road Safety and Simulation (Vol. 21, pp. 14-16). Indianapolis Indiana, United States: National Academy of Sciences.
- Mondal, S., Singh, D. and Kumar, R., 2022. Crime hotspot detection using statistical and geospatial methods: a case study of Pune City, Maharashtra, India. *GeoJournal*, 87(6), pp.5287-5303.
- Mukhopadhyay, D. (1999). Geography of urban crime against women: comparative study of Calcutta and Toronto. Thesis, Jawaharlal Nehru University, New Delhi.
- Ord, J.K. and Getis, A., 1995. Local spatial autocorrelation statistics: distributional issues and an application. *Geographical analysis*, 27(4), pp.286-306.
- Peeters, A., Zude, M., Käthner, J., Ünlü, M., Kanber, R., Hetzroni, A., Gebbers, R. and Ben-Gal, A., 2015. Getis-Ord's hot-and cold-spot statistics as a basis for multivariate spatial clustering of orchard tree data. *Computers and Electronics in Agriculture*, 111, pp.140-150.
- Zakaria, S., & Rahman, N. A. (2015). Analyzing the violent crime patterns in Peninsular Malaysia: Exploratory spatial data analysis (ESDA) Approach. *Jurnal Teknologi*, 72(1).

--Tanisha Sharma  
Ph.D. Scholar  
Department of Geography  
Central University of Haryana

--Dr. Cheetar Mal Meena  
Assistant Professor  
Department of Geography  
Central University of Haryana



## **ASSESSMENT OF GREEN COVER SUSTAINABILITY-A CASE STUDY OF SONIPAT CITY**

Dr. Seema and Dr. Mehtab Singh

### **Abstract**

Green infrastructure within cities performs a critical function in urban planning by helping foster sustainable development. It cultivates healthful living conditions for residents while delivering valuable ecosystem services that benefit both people and biodiversity. As urbanization accelerates and populations grow faster than infrastructure, strategic management of land resources is urgently needed to prioritize allocating adequate green spaces. Insufficient urban green areas can adversely impact public health and quality of life. Maintaining green cover is therefore vital to city sustainability, livability, and resilience against environmental challenges from rapid development. This study aims to comprehensively evaluate the sustainability of green cover in the city of Sonipat, Haryana through analysis of its spatial distribution and availability during different seasons using the Normalized Difference Vegetation Index (NDVI) remote sensing technique. The existing green cover area during pre-monsoon and post-monsoon periods has been quantified and the regions with consistent vegetation throughout the year have been identified. The findings have been compared with standards prescribed by the Ministry of Urban and Regional Development Plan Formulation and Implementation (URDPFI) guidelines for allocation of recreational land in cities. Potential sites suitable for expansion of green cover have been identified through constraints mapping of various land use/land cover features in the city along with applying a weighted scoring system of suitability criteria. The study findings indicate a severe deficiency of areas under permanent green spaces within Sonipat city limits in comparison to the mandatory norms. To remedy this imbalance and propose remedial measures, strategic recommendations have been put forth for targeted plantation drives in the city periphery, along major transportation corridors, and on appropriate rooftop surfaces and vacant lands. If implemented effectively, these measures can help optimally augment the existing green cover footprint and restore a balanced development approach in the city to counter the pressures of rapid urbanization and enable long-term environmental sustainability.

## **Introduction**

Urban green cover plays a vital role in urban planning and is an important part of developing sustainable cities. It helps foster a healthy living environment and provides ecosystem services benefiting both urban residents and biodiversity. As cities rapidly urbanize, there is increasing pressure on land resources and a need to carefully allocate space for different urban functions, including sufficient green space (Anguluri and Narayanan, 2017). Lack of access to urban green spaces can negatively impact public health and quality of life. Vegetation cover has always been emphasized in urban areas for better environmental quality (Ferrini et al., 2020) where trees are significant climate modifiers (Fryd et al., 2012). Green cover is beneficial over a broader range of benefits in social, economic and ecological aspects (Dale et al., 2005; Govindarajulu, 2014; Wolf and Robbins, 2015; Ramaiah and Avtar, 2019). Sundaram (2022) noted that vegetation can be proposed as Green Infrastructure Plan in hubs and corridors at the city level, neighborhoods or ward level gardens, linking green corridors with large open spaces or important areas or buildings and thus facilitating green areas in cities. Decisions on land use, surface water management, agricultural practices, building design and construction, energy management as well as law-making and enforcement are important aspect of sustainable development in cities (Rasul, 2016). Integration of environmental protection goals into mainstream social and economic policy-making is necessary to ensure green cover sustainability in cities. Rapid urbanization has transformed landscapes and placed tremendous pressure on resources in cities across India (Bharath et al., 2018). As population growth outpaces urban planning, there is an urgent need to thoughtfully manage urban development and prioritize the allocation of green spaces to support long-term sustainability and livability (Avtar et al., 2019). This paper examines the status of green cover in the city of Sonipat, Haryana to evaluate its sustainability and propose remedial measures. Sonipat has emerged as an important urban center due to its proximity to Delhi and the development of educational and industrial sectors (Kumar, 2018). However, like many fast-growing cities, high population growth poses challenges for infrastructure and civic amenities.

## **Study Region**

Sonipat city is located to the north of the National Capital Territory of Delhi. The distance between Sonipat and Delhi by road is 52 kms and by rail route it is 44 kms. Sonipat is now one of the most important cities in the state of Haryana because of the large number of schools and colleges that provide educational

opportunities to its residents as well as students from all over the state. Sonipat is also an important agricultural center with crops like wheat and sugarcane. It also has industries like cotton textiles, paper, engineering products etc.

The Municipal Committee of Sonipat was originally formed in 1933 with a population of only around 15,000 people. However, based on the census records the town's population has since grown exponentially. It increased from 1,43,922 in 1991 to 2,89,333 by 2011 representing a staggering rise of over 100 per cent in just 20 years. This dramatic surge in population has been mainly fueled by the city's close proximity to Delhi, which has made it an attractive location for many people working in the capital. Its main commercial and administrative areas are situated around 5 km east of National Highway No. 1, which has contributed greatly to the town's development and connectivity with Delhi as well as other major cities. The civic administration of Sonipat city has undergone significant expansion in recent years to keep up with the city's rapid growth. Before 2015, the total area under the jurisdiction of the Municipal Council of Sonipat was 40.75 square kilometers. However, given the ample rise in both population size and geographical extent of the urban local body, the Government of Haryana designated Municipal Council Sonipat as a Municipal Corporation in 2015. This upgraded the civic body's status to that of a municipal corporation and it oversees and manages the civic infrastructure, public services and administration within the city limits. The geographical area administered by the new Municipal Corporation of Sonipat was vastly increased to 181.3 square kilometers to reflect the city's expanded limits. However, the present study considers the original 40.75 square kilometer area that was previously under the municipal council.

### **Objectives**

- (1) To evaluate the green cover sustainability of Sonipat city.
- (2) To suggest suitable sites for green cover expansion in Sonipat city.

### **Database and Methodology**

Urban green spaces in particular require strategic planning to ensure adequate provision as land use patterns transform (Pramanik and Punia, 2019). This study analyzes the existing green cover distribution and area in Sonipat city during different seasons using geospatial techniques such as NDVI. It aims to quantify available green space as per the Ministry of Urban Development guidelines and assess deficiencies. Furthermore, potential expansion sites are identified by constraints mapping of land use/land cover features. The green cover area in

Sonipat city is calculated using NDVI for pre-monsoon and post-monsoon periods. NDVI is a useful remote sensing technique for detecting field surface features valuable for policymaking and planning. It quantifies vegetation by measuring the difference in reflectance of near-infrared light, which plants strongly reflect, and red light, which is absorbed. NDVI values range from -1 to +1, with non-vegetation below zero. Values closer to +1 indicate dense vegetation, while values near zero suggest urban areas due to higher reflectance of infrared and green light compared to other wavelengths by healthy chlorophyll vegetation which our eyes perceive as green absorbing more red and blue light. Furthermore, the selection of suitable sites for green cover expansion in Sonipat city is based on a set of local criteria. Qualities like current land use, land cover, water availability and distance from other features impact a site's suitability for uses such as parks or trees. To assess suitability, a scoring and weighting system is applied to factors such as these. Relevant geospatial layers have been constructed using data from satellites, maps and field studies on criteria such as existing land use and distance from habitations. All suitable layers are integrated to identify potential areas by applying the weighted scoring methods. This helps determine locations most suitable to fulfill the recreational and environmental needs of the city in a sustainable manner.

## **Results and Discussion**

India witnessed a high rate of urban population growth between 2001 and 2011, with numbers rising by 29.38 per cent (Mukhopadhyay et al., 2016). This rapid pace of urbanization and the resultant urban sprawl placed tremendous pressure on cities and had adverse effects. As cities expanded unconventionally to adjust the surging populations, cities became more prone to the negative impacts of rapid and unplanned urbanization. The sudden rise in urban populations also deteriorated the availability of green spaces across metropolitan areas (Basu and Das, 2023). Since recreational lands couldn't keep pace with the intensifying urbanization, adequate areas to meet the recreational needs of the growing populations could not be ensured. As a result, the quality of urban habitats declined substantially. The Ministry of Urban Development's 1996 URDPFI guidelines outline standards for allocating recreational land area across different city types. Accordingly, small towns should dedicate between 12 to 14 per cent of their developed land for recreation, while for medium and large cities this proportion is 18 to 20 percent. Metropolitan areas require 20 to 25 per cent recreational space. Acceptable recreational features include open fields, parks, botanical gardens, waterbodies, playgrounds and other natural landscapes used for public leisure.

### Analyzing the green cover in Sonipat city

As evident from **Table-1**, the area under green spaces in Sonipat city was quite less in the year 2011. With a total area of 3,963 hectares and population of 2,78,149, there was only 248 hectares of land dedicated to green belts and open fields, accounting for a meagre 6.25 per cent of the total area (Table-2). This is much lower than the recommended 12-14per cent for a small town as per URDPFI guidelines.

Table-1: Area under Green Spaces in Sonipat City

Land Use (Year)	Population	Total Area in ha.	Area under Green Belts and Open Spaces in ha.	Area in % of total Area (Green and Open Spaces)
2011	278149	3963	248	6.25
2021	361,000	12468	1065	8.54

Source: Compiled from Master Plans of Sonipat City

As per projections in the Master Plan, by 2021 the population was expected to rise to 3,61,000 with total area expanding to 12,468 hectares. However, the planned area for green spaces showed only a marginal increase to 1,065 hectares, which was merely 8.54per cent of the total area. Thus, even in the future vision, the provision for recreational green cover fell short of the 18-20 per cent standard for a medium sized city. The dismally low allocation of land to environment-friendly green spaces in both analysis years reflects the inadequate priority given to urban green cover and landscape management in Sonipat despite its high urbanization rate.

### Green Cover during Pre-Monsoon Period

The NDVI analysis during the pre-monsoon period revealed some key insights about Sonipat city's green cover distribution. The total area calculated under vegetation was 6.70 sq km, which accounted for 16.44 per cent of the total geographical area. However, this proportion fell short of the recommended 18-20 per cent benchmark for a medium-sized town. As indicated in **Fig. 1**, a significant reduction in green cover was observed mainly in the central regions of the city during this period. This could be attributed to the dense concentration of residential and industrial developments in these zones leaving little room for green cover. On the other hand, the peripheral sections emerged as potential areas for expansion with substantially more unoccupied lands that could support expansion of green cover through plantation drives and urban forestry initiatives. The pre-monsoon NDVI data thus highlighted the deficiencies in green space

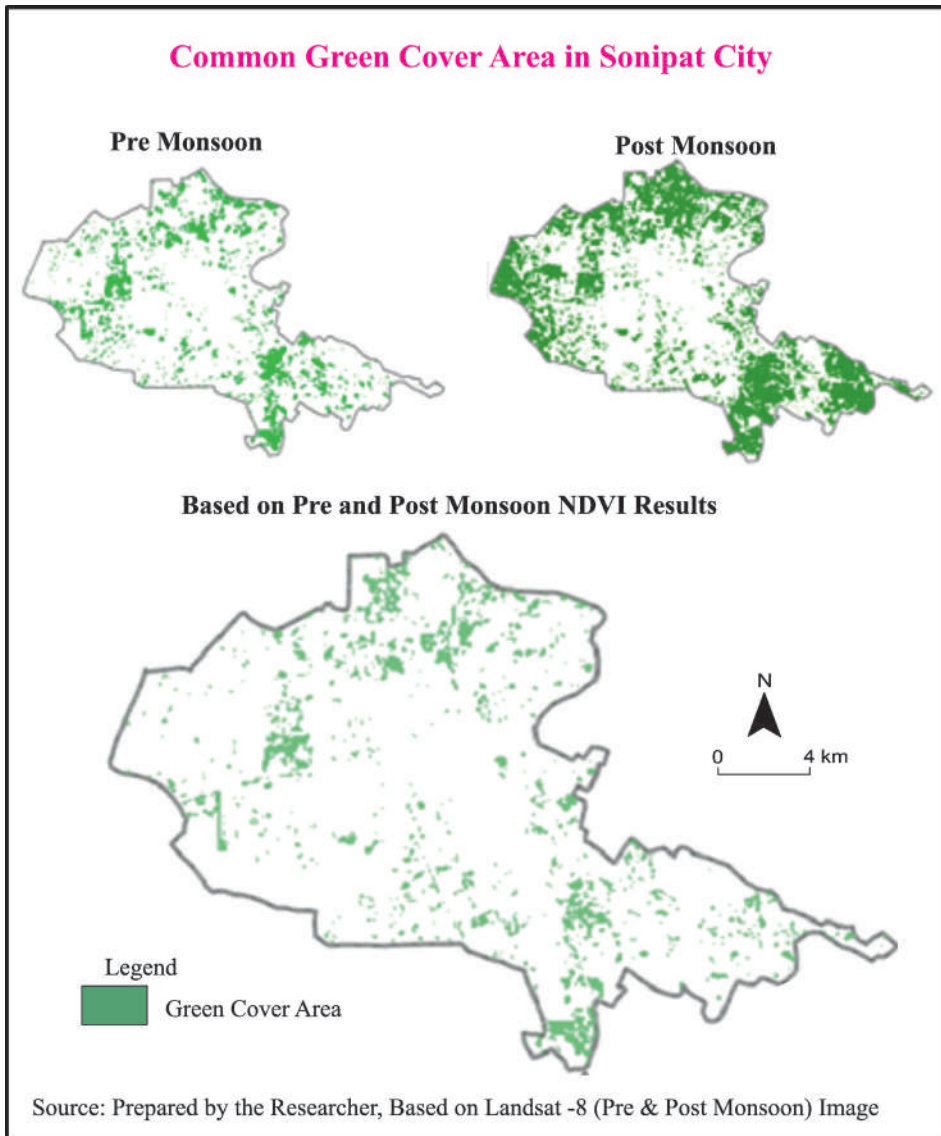


Fig. 1

availability at the city center while also identifying the opportunities present towards the outskirts of the city.

### **Green Cover during Post-Monsoon Period**

The NDVI analysis during the post-monsoon period revealed a significant increase in Sonipat city's overall green cover. As per the results, the total vegetation area increased to 10.37 sq km which accounted for 25.46 per cent of the geographical area. A few important patterns were observed. As shown in **Fig. 1**, there was a dramatic growth in greenness particularly in places which had little pre-monsoon green cover. This indicated that the onset of the season benefited those parts of the city which lacked natural water sources earlier. Secondly, the NDVI data mirrored the pre-monsoon trend by showing maximum green cover towards the outskirts rather than the city center. This could be linked to lower anthropogenic pressures like reduced construction and industrial activity at the fringes allowing green cover proliferation post monsoon. However, the lack of evenly distributed green cover highlighted the need for a planned green infrastructure to make ecological gains sustainable throughout the year.

### **Common Area of Green Covers in Both Pre and Post Monsoon**

In order to truly determine the status of permanent green cover in Sonipat city, it is crucial to analyze the areas that remained under vegetation throughout the year. Simply assessing pre-monsoon and post-monsoon NDVI values individually do not indicate fixed green cover extent. As seen in **Fig. 1**, the pre-monsoon green cover of 16.44 per cent did not meet the recommended 18-20% standard for a medium-sized town. However, the post-monsoon green cover increased substantially to 25.46 per cent. Hence, the NDVI images of both periods were overlaid to identify zones that were commonly vegetated during and after monsoon season. This helped filter out temporary green cover and identify regions with green cover throughout the year. The analysis revealed that the area of consistent green cover through the annual cycle was only 11.11 per cent of the total geographical area. During the pre-monsoon analysis conducted in May 2013, the total vegetation area was 6.70 sq km which translated to 16.44 per cent of the city geographically. Post-monsoon readings from September 2014 revealed a sizeable increase with 10.37 sq km or 25.46 per cent area under green cover. This affirmed the ability of monsoon rains to temporarily boost green cover in the city. However, critically examining the common green zone established the year-long green cover extent to be only 4.53 sq km or 11.11 per cent. While pre-monsoon green cover share fell short of norms,

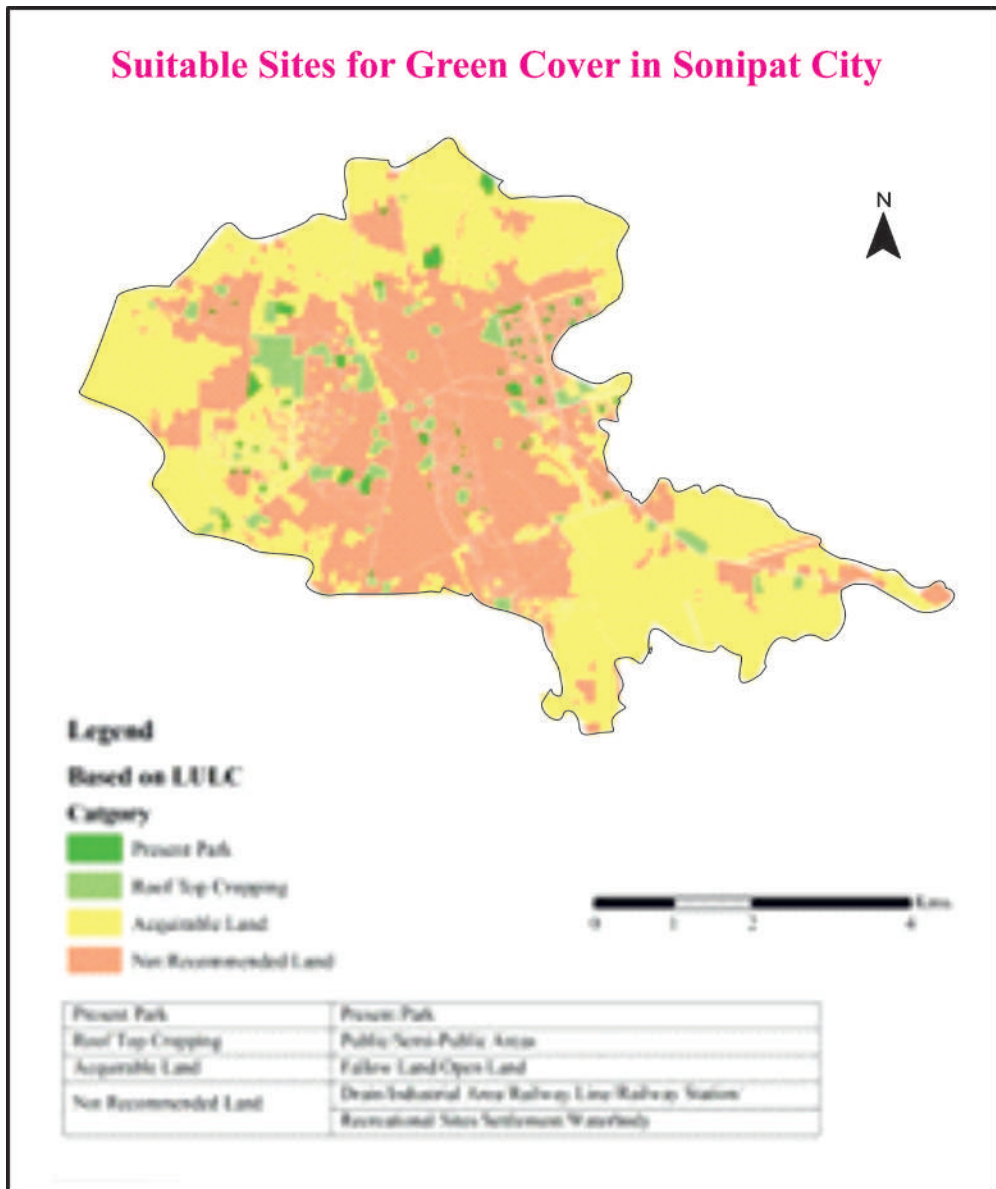


Fig. 2

even the combined average of 11.11 per cent for all periods grossly underestimated the URDPFI prescribed 18-20 per cent for Sonipat's land to be under permanent green cover. While this confirmed severe green space deficits vis-a-vis planning norms, it also underscored the need for strategic management to optimize vegetation across all seasons in Sonipat through sustainable landscaping and forestry. The superimposed NDVI approach facilitated a refined understanding of the city's green cover throughout the year.

### **Suggestions and Remedial Measures for Sustainable Green Cover**

Sustainable land use aims to balance development needs with environmental protection through judicious planning and management of land resources. As Sonipat witnessed rapid urbanization outpacing infrastructure growth, its land use emerged unsystematic and inequitable. Sonipat has undergone rapid demographic and physical expansion in the recent past as a result of rising population levels. The rapid urbanization has converted vast tracts of land while civic amenities have struggled to keep pace with demands. As a consequence, the city's infrastructure and resource base are under immense pressure. Many services like water supply, sewage treatment and power provision are struggling to meet demand owing to unorganized development. Large tracts were consumed for residential and industrial activities while allocation for green spaces and agriculture remained inadequate which has led to biodiversity loss and ecological fragility (**Fig. 2**). As a growing urban center, Sonipat must transition towards planned and optimum utilization of land to realize long-term sustainability. This section puts forth several proposals to guide the city's land use in an equitable and sustainable manner. Focusing on integrated zoning, restoring green belts and promoting urban agriculture are some corrective strategies outlined that would enable the city to restore balance between development and conservation priorities. With only 11 per cent of its area under vegetation, Sonipat falls short of the mandated green cover for a medium-sized city. As per URDPFI guidelines, it should ideally have between 18-20 per cent land dedicated to recreation and environmental assets. Even the minimum 9 per cent benchmark is not being fulfilled. Moreover, incorporation of sustainability principles through long-term plans and policies remains a challenge.

To remedy this, strategic spatial analysis of the city has been carried out using remote sensing and mapping techniques. The current scenario of green cover distribution, land allocation and land use patterns were assessed from different data sources as depicted in the information. Potential sites for augmenting green areas were subsequently identified based on the land cover assessment.

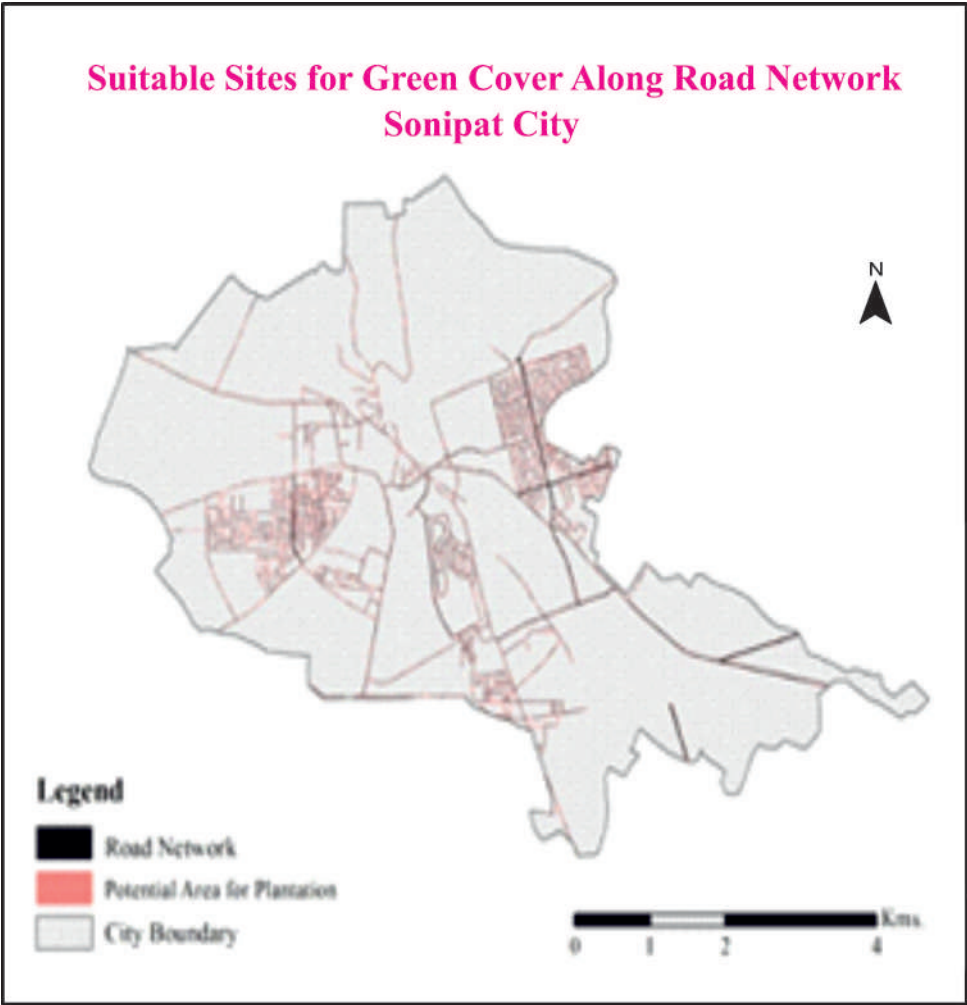


Fig. 3

This will help Sonipat city comply with regulations and optimally distribute green infrastructure for a healthier urban ecosystem. The identified zones provide opportunities to expand green cover in the city. Sonipat exhibits fairly conducive terrain features to boost its green cover through strategic landscape planning. The topographical analysis as depicted in **Fig. 2** reveals that almost all areas of the city are suitable for increasing vegetation, with the exception of some pockets. The "Not Recommended Land" zones have existing urban development in the form of dense residential clusters, public utilities and commercial hubs which constrain extension of green cover in these locations. However, majority of the remaining territory classified as "Acquirable Land" presents a major opportunity to expand the green cover footprint, especially towards the northern and southern outskirts. Given the amenable terrain and accessibility of large tracts, focused afforestation drives can be carried out in these regions. This will aid the city's progress in complying with mandated recreational space norms. The topography thus acts as a facilitator for targeted augmentation of green cover in Sonipat city. As shown in the **Fig. 2**, the roadside corridors emerge as highly feasible zones for expanding Sonipat's green cover footprint in a targeted manner. The state highways in the city limits, namely S.H-11 and S.H-14, provide substantial area that can be capitalized through tree plantation. In addition, several key intra-city routes such as Gohana Road, Kakroi Road, Mahlana Road, Purkhas Road, Narela Road, Murthal Road and Ganaur Road traverse various residential and commercial pockets thereby presenting continuous linear spaces suitable for green cover expansion. This is complemented by the median strips and edges along roads crisscrossing different sectors and model towns. Facilitating vegetation of these transport networks can help join fragmented green patches into wider ecological corridors.

This integrative approach will enhance commute experience while boosting the overall green cover in the most optimal way. The center of Sonipat city faces severe constraints in expanding green spaces due to intensive land-use conversion for residential and commercial development over the decades. As a result of congested habitations and dense business activity, there exists very little vacant territory that can be set aside for additional vegetation in this core urban zone. However, the figures indicate viable alternative sites such as rooftops of houses and civic buildings. Tapping into these unconventional micro-spaces holds untapped potential for augmenting the city's overall green footprint. A strategic tree planting initiative targeting appropriate rooftop surfaces can significantly boost vegetation cover without requiring any new land acquisition. The rooftops of houses in dense communities and public facilities are well-suited for shallow-rooted plantations

due to their extensive coverage and accessibility. Rooftop gardening can be incentivized among citizens to harness private spaces for the common good. Similarly, existing parks and vacant lands have potential to host more vegetation. Tapping such diverse sites through innovative strategies can catalyze faster attainment of mandated standards for optimal green cover in the city.

## **Conclusion**

The study conducted a thorough evaluation of the green cover sustainability in Sonipat city. NDVI analysis during pre-monsoon and post-monsoon periods revealed that the existing vegetation cover is significantly below the minimum benchmarks prescribed by the URDPFI guidelines for a medium-sized town. While green cover increased temporarily post-monsoon, the areas that retained consistent green cover throughout the year were found to be alarmingly low. This clearly indicates inadequate allocation and management of permanent green spaces in the city. To remedy the shortfalls, potential suitable sites for expanding green cover were identified, primarily near the outskirts and along major transport corridors. Additionally, a focused planting initiative including rooftop gardening and plantation in vacant lands has been proposed to augment and accelerate the green cover expansion.

Unless prompt corrective measures are implemented to expand the green cover in the city, specifically through integrated zoning and focused plantation drives, the city's rapid growth will likely continue to outpace efforts to maintain ecological balance, leading to issues such as increased pollution, loss of biodiversity, and diminished quality of life for residents. Therefore, immediate measures are crucial to restore the essential balance between rapid urbanization and long-term environmental sustainability in the city.

## **References**

- Anguluri, R., & Narayanan, P. (2017). Role of green space in urban planning: Outlook towards smart cities. *Urban Forestry & Urban Greening*, 25, 58-65.
- Avtar, R., Tripathi, S., Aggarwal, A. K., & Kumar, P. (2019). Population–urbanization–energy nexus: a review. *Resources*, 8(3), 136.
- Basu, T., & Das, A. (2023). Urbanization induced degradation of urban green space and its association to the land surface temperature in a medium-class city in India. *Sustainable Cities and Society*, 90, 104373.
- Bharath, H. A., Chandan, M. C., Vinay, S., & Ramachandra, T. V. (2018). Modelling urban dynamics in rapidly urbanising Indian cities. *The Egyptian Journal of Remote Sensing and Space Science*, 21(3), 201-210.
- Dale, V., Archer, S., Chang, M., & Ojima, D. (2005). Ecological impacts and mitigation strategies for rural land management. *Ecological Applications*, 15(6), 1879-1892.

- Ferrini, F., Fini, A., Mori, J., & Gori, A. (2020). Role of vegetation as a mitigating factor in the urban context. *Sustainability*, 12(10), 4247.
- Fryd, O., Pauleit, S., & Bühler, O. (2012). The role of urban green space and trees in relation to climate change. *CABI Reviews*, (2011), 1-18.
- Govindarajulu, D. (2014). Urban green space planning for climate adaptation in Indian cities. *Urban climate*, 10, 35-41.
- Kumar, S. (2018). Socio-economic impact of urbanisation on peripheral villages of Sonipat city: Observation from Haryana state. *IAHRW International Journal of Social Sciences Review*, 6(2), 268-274.
- Mukhopadhyay, P., Zerah, M. H., Samanta, G., & Maria, A. (2016). Understanding India's urban frontier: what is behind the emergence of census towns in India?. *World Bank Policy Research Working Paper*, (7923).
- Pramanik, S., & Punia, M. (2019). Assessment of green space cooling effects in dense urban landscape: A case study of Delhi, India. *Modeling Earth Systems and Environment*, 5, 867-884.
- Ramaiah, M., & Avtar, R. (2019). Urban green spaces and their need in cities of rapidly urbanizing India: A review. *Urban science*, 3(3), 94.
- Rasul, G. (2016). Managing the food, water, and energy nexus for achieving the Sustainable Development Goals in South Asia. *Environmental development*, 18, 14-25.
- Seema. Suman. and Kaushik S. P. 2015. Urban Sprawl and Land Use / Land Cover Analysis of Sonipat City Using Remote Sensing Technology, *International Journal of Scientific Engineering and Research*, 62(86), 351-357.
- Seema. and Singh, Mehtab. (2019). Environmental Issues of Urban Areas with Special Reference to Sonipat City, *RESEARCH REVIEW International Journal of Multidisciplinary*, 4, 77-82.
- Seema. and Singh, Mehtab. (2021). Sustainability of Urban Places: A Case Study Of Sonipat City, Unpublished Ph.D. Thesis, Department of Geography, Maharshi Dayanand University, Rohtak.
- Sundaram, A. M. (2022). Restoring Urban Green Cover of Chennai City: An Ecological Approach. In *Environmental Concerns and Remediation: Proceedings of F-EIR Conference 2021* (pp. 145-171). Cham: Springer International Publishing.
- Wolf, K. L., & Robbins, A. S. (2015). Metro nature, environmental health, and economic value. *Environmental health perspectives*, 123(5), 390-398.

--Dr. Seema  
Assistant Professor  
Department of Geography  
M.K.J.K College, Rohtak

--Dr. Mehtab Singh  
Professor  
Department of Geography  
M.D. University, Haryana



## **BEYOND THE CITY EDGES, URBAN EXPANSION IN PERI-URBAN HISAR, INDIA- A LANDSCAPE METRICS AND SHANNON ENTROPY INDEX APPROACH**

Rahul and Ravinder Kaur

### **Abstract**

The rising population is a global phenomenon that triggers an upsurge in the urban population. Consequently, urban settlements grow and expand. This process of urbanization causes alteration in the landscape of peri-urban areas. It is a subject of major concern, mainly for developing nations. The main reasons for the landscape alteration and transformation in peri-urban areas are: high population growth rate, migration, conversion of rural areas into urban landscapes, speculation and infrastructure development etc. The process of urbanization is directly linked to built-up or urban expansion. The focus of this study is to measure and analyze the built-up expansion in the peri-urban Hisar. Which is being achieved by collecting Landsat images from 1991, 2001, 2011, 2021 and 2023. The urban expansion is measured by allying various indices, namely: annual growth rate, built-up expansion intensity index (BEII), Shannon entropy, relative entropy and landscape metrics. The result of the study indicated that there is continuous built-up expansion and the composition of the built-up area in the peri-urban Hisar is in dispersed and fragmented manner. The findings of the study ultimately help urban planners with better planning and land management to achieve sustainable urban development in peri-urban Hisar with leading awareness and understanding.

### **Introduction**

When the size of a city expands, it absorbs neighboring communities and their residents, which were hitherto categorized as rural areas (Jiang & O'Neill, 2018; Chandrasekhar & Sharma, 2015; Weller et al., 1971). The process of urban transformation and expansion is a dynamic and multifaceted socioeconomic phenomenon that is interconnected with numerous natural and manmade causes, the most important of which are demographic and economic considerations. As the world's population continues to urbanize, there is emerging concern over land consumption, particularly urban encroachment onto non-urban territory.

Rapid growth of urban construction has been a defining feature of urban land-use change on the city periphery (Dutta et al., 2020; Li et al., 2016; McFarland, 2015). Due to the sheer expansion of cities, an urban fringe area with both urban and rural traits has formed, and the dynamic phenomenon of peri-urbanizations has evolved. The cities' tremendous outward expansion as well as changing habitation and land use, have changed adjacent rural hinterland of the cities into semi-urban or peri-urban regions (Shaw & Das, 2018). This study focuses solely on pattern and process of the urban expansion in peri urban area, Hisar. For effective planning and administration, it is crucial to comprehend the spatio-temporal patterns of built-up growth and sprawl in peri-urban areas. The current study makes a contribution by using geospatial approaches to analyze the temporal trends of urban expansion in the peri-urban Hisar. The principal objective of this research is to investigate the process and general trajectory of built-up expansion by utilizing various quantitative techniques.

### **Study Region**

The peri-urban Hisar is selected for the present study. As peri-urban areas are typically defined as transitional zones on the fringes of a city boundary where rural and urban traits are collided. In the present scenario peri-urban area is under the massive alteration and transformation. In 1354 AD, Firoz Shah Tughlaq established Hisar city as "Hisar-e-Firoza." Hisar city serves as the administrative headquarters of the district Hisar in the state of Haryana, India. It is located 165 km in north-west direction from the nation capital New Delhi. Hisar served as a counter-magnet city of the nation capital region- Delhi because of its strategic location and it was the first counter magnet city of Haryana declared in 2001. The peri-urban area of Hisar city has been delimited with the help of seven variable from three different dimensions namely Demographic, Economic and Administrative. The peri urban area of Hisar city covers 77662.08 hectares (776.62 sq. kms). The peri-urban area extends between 13 and 23 km from the city center; its extent is greater in the west and south of the city than in the north and east.

### **Objective**

The present paper aims to study the Built-up expansion with the help of Landscape Metrics and Shannon Entropy Index.

### **Materials and Methodology**

The multi-temporal and multispectral satellite images enact remarkable tool in the examination and study of urban expansion and land use transformation.

The purpose of this study is achieved by using, imageries of satellite namely: Landsat 5 TM and 8 OIL\_TRIS (**Table-1**). The Landsat images for the years 1991, 2001, 2011, 2021 and 2023 are used for this study. These imageries have been acquired from the USGS Earth Explorer.

Table-1: Acquired Satellite Images Information

Satellite	Date	Path and Row	Sensor	Spatial Resolution	Source
Landsat 5	05/03/1991	147/40	TM	30 Meter	USGS
Landsat 5	16/03/2001	147/40	TM	30 Meter	USGS
Landsat 5	12/03/2011	147/40	TM	30 Meter	USGS
Landsat 8	07/03/2021	147/40	OLI_TIRS	30 Meter	USGS
Landsat 8	05/03/2023	147/40	OLI_TIRS	30 Meter	USGS

Source: Authors

Availability and data quality are also taken into account while selecting the imageries. Most importantly, to avoid the seasonal impact on the image classification, all the images have been taken from the same season and month. All the other ancillary data, such as maps of Hisar city and village boundaries, etc., that fulfil the objective of the study have been collected from the Survey of India and Town and Country Planning, Haryana. The acquired images were processed with the help of Erdas Imagine geospatial software. At the initial stage, different bands were stacked to obtain a multispectral image of all the considered years (1991, 2001, 2011, 2021 and 2023). After obtaining the multi spectral or band images, a subset was created with the help of boundaries of the area of interest (AOI), which is the peri-urban area of Hisar city (**Fig. 2**). The subset, or clipped images of all the considered years were pre-processed for enhancing the image quality and better visual interpretation. The image enhancement was followed by the image classification. All the images have been classified with the supervised image classification approach and supporting with maximum likelihood method the images, classified into six different classes include Water bodies, Built-up, Agriculture, Vegetation, Open land and Mining. After classifying all the images, accuracy assessment has been carried out over all the images by employing the ground truthing points. It is a significant step in the image classification process; accuracy assessment serves to safeguard the reliability and proficiency of the map. All the images have been classified, having overall accuracy of more than 88 percent and a kappa coefficient of more than 0.86.

Finally, the LULC maps of all considered years were prepared and the statistics of maps were used for further analysis. Further to study the direction of urban expansion, the area of interest was divided into 8 directions.

### **Change in Built-up Area**

In the examination and exploration of urban expansion, change in built-up area is simplest as well as easiest method to investigate the increment of built-up area in the spatio-temporal frame (Fig. 2 and 3). The spatio-temporal variation in built-up expansion in the research area is examined by utilizing three indices: the net change, percentage change and the annual growth rate in built-up expansion. These indices are helpful for examining the absolute and relative changes in built-up area over the period of time.

### **Built-up Expansion Intensity Index (BEII)**

The BEII could be applied to quantify and examine the built-up spatial expansion differences. Additionally, the BEII is used for determine the preference for built-up growth because built-up expansion vary based on the region and the direction in which it occurs, depending upon various driving factors (Alsharif & Pradhan 2014; Ren et al., 2013). The Built-up Expansion Intensity Index is divided into following standards: very low magnitude (0 to 0.28); low magnitude (0.28 to 0.59); medium magnitude (0.59-1.05); high magnitude (1.05-1.92); and very high magnitude (>1.92) of development (Alsharif et al., 2014).

### **Shannon's Entropy**

It is frequently applied to determine the spatial concentration and dispersion of a given phenomenon (Sahana et al., 2018; Sudhira et al., 2004; Yeh & li, 2001). The current study employed Absolute and Relative Entropy for determining the degree to which built-up is concentrated and dispersed in the peri urban area of Hisar. The entropy approach, which allows us to examine the geographic dispersion of spatial phenomena, reveals the orientation as well as configuration the of spatial patterns and variables. (Mithun et al., 2016). The values of absolute entropy fluctuate between 0 to  $\log(n)$ . The value of Entropy closer to 0 indicates an extremely compactly distributed Built-up area, whereas value closest to  $\log(n)$  indicates an extremely dispersed built-up distribution. On the other hand, Relative entropy is quantified using a scale with the values that stretch from 0 to 1. It provides a more precise assessment of urban sprawl. When the value of relative entropy is towards 0, it represents a packed built-up distribution, and when it is dearer to 1, it reflects a highly dispersed distribution of built-up.

**Built-up Landscape Metrics Analysis**

Landscape metrics is a form of quantifiable measure meant for evaluating and analyzing the pattern and structure of land use (McGarigal, 1995). Variety of methods to measure landscape metrics are used to configure different land classes. In the present study, the spatio-temporal trends of urban expansion are measured by utilizing different metrics at the class level as shown in **Table-2**. And these landscape metrics are calculated by using the FRAGSTATS software.

Table-2: Landscape Metrics Used for Analyzing Built-up Expansion

Landscape metrics	Interpretations	Range	Relation with Fragmentation
Number of Patch (NP)	High NP represent fragmentation and sprawl of corresponding class	NP > 1, without limit.	Positive
Patch Density (PD)	Increasing PD= fragmentation, scatter Decreasing PD= infilling, aggregation	PD > 0, without limit.	Positive
Edge density (ED)	Quantify the raggedness or complexity of the landscape High ED: complex or ragged	ED ≥ 0, Without limit	Positive
Mean Patch Size (MPS)	High MPS means expansion and sprawl, Low MPS shows the fragmentation of classes	MPS > 0, without limit.	Negative
Largest Patch Index (LPI)	LPI gets near to 0, the largest patch shrinks; when LPI become 100, the entire landscape contains the sole patch of the recognizing class.	0 < LPI ≤ 100	Negative

Source: Authors

**Results and Discussion**

**Analysis of Built-up Expansion**

The distribution of Built-up area in peri-urban Hisar has been derived with the help of classified image of different time periods. At the first, built-up area of different

time period was calculated and compared. The output statistics of classified images are shown in the **Table-3**. The findings reveal that the built-up area of peri urban Hisar in the year 1991 was 2179.71 hectare, consisting 2.81 percent of total area and in 2001 it was 2850.30 hectare and its share to total area was 3.67 percent. The Built-up area, during the first decade of the study was increased by 670.59 hectare in absolute number and in the relative terms it was increased by the 30.77 percent. The annual rate of increase during the period of 1991-2001 was 3.08 percent. The built- up area was rose to 3695.94 hectare in the year 2011 which consists 4.76 percent of the total area. When compared to the built-up area of the year 2001, it has been noted that the total area of built-up was increased by 845.64 hectare. Over the course of second decade of the study period, from 2001 to 2011, the proportion of built-up area increased by 29.67%. During this period the annual rate of Built-up expansion was 2.97 percent, lower than the 1991-2001. In the year 2021 the area under the built-up was 6893.01 hectare and its share to the total area of peri urban Hisar was 8.88 percent. During the third decade of the study that is 2011-2021, the built-up area was increased by 3197.07 hectare, in the terms of percentage, it was increased by 86.50 percent. The built-up area was increased by 8.65 percent per year during 2011-2021. That is much higher than the earlier period. In 2023, there were 6993.09 hectares of built-up land, which made about 9% of the total area. During the year 2021 and 2023 the total built-up area increased by 100 hectares (Table-3). It was increase by 1.45 percent in the last two years of the study and the annual rate of increase in the built-up area was only 0.15 percent in this duration (**Fig. 1**).

Table-3: Built-up Area (1991 to 2023)

Years	Area (ha)	Area (%) (Proportion to total area)	Change in Area (ha)	Change in area (%)	Annual rate of change (%)
1991	2179.71	2.81	-	-	-
2001	2850.30	3.67	670.59	30.77	3.08
2011	3695.94	4.76	845.64	29.67	2.97
2021	6893.01	8.88	3197.07	86.50	8.65
2023	6993.09	9.00	100.08	1.45	0.15

Source: Authors

Note: Unit is in hectare

The overall share of the built-up in the total peri-urban area increasing continuously from 2.81 percent in 1991 to 9.0 percent in 2023. In the initial decades of the study, the share of built-up area rises slowly. However, the proportional

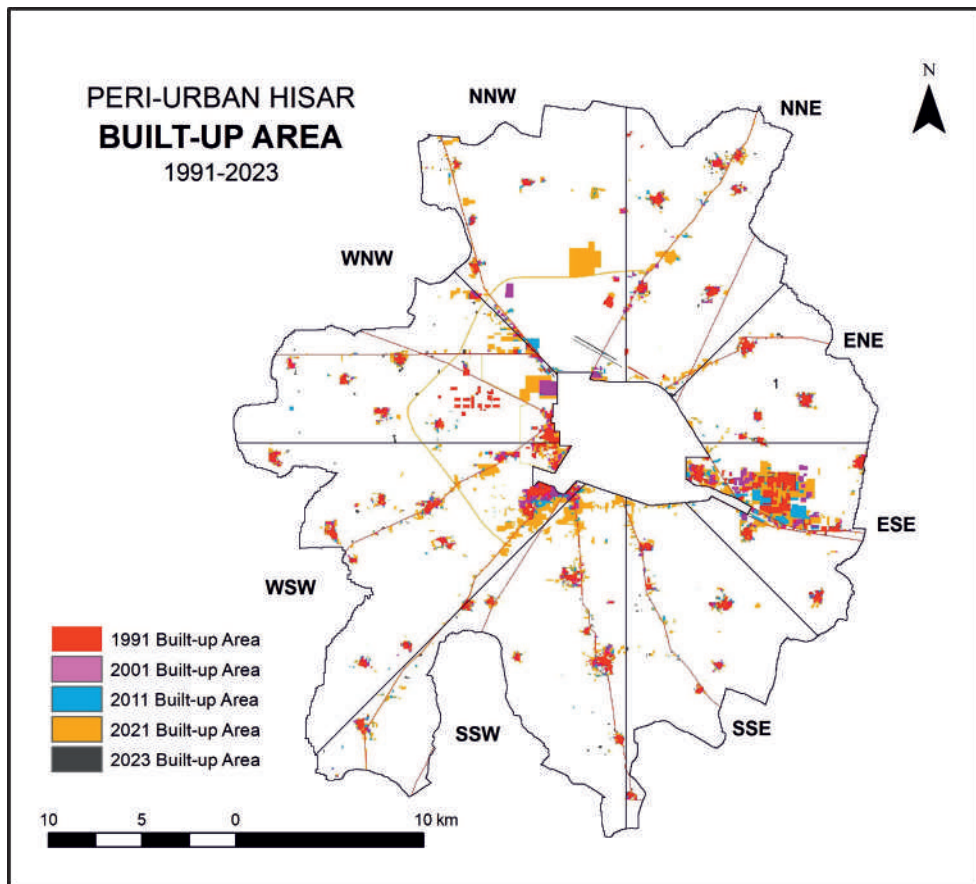


Fig. 1

percentage of built-up area suddenly increased from 4.76 percent in 2011 to 8.88 percent in 2021. Annual growth rate of built-up expansion is shown in the **Table-3**. The result shows that in the initial two decades (1991–2011), the annual growth rate was approximately 3 percent. But there was a sudden spike during 2011–2021, when the annual growth rate of built-up expansion increased to 8.65 percent. The annual growth rate for the time period of 2021–2023 was only 0.15 percent.

### **Directional Analysis of Built-up Expansion**

For analyzing the directional distribution and expansion of the built-up area, the whole study area is divided into eight directions (**Figures 1 and Table-4**). The result of the directional distribution of built-up area is shown in **Table-4**. A significant amount of the built-up space in 1991, which was 538.56 hectare or 24.71 percent of the total built-up area, was located in the ESE direction. The ESE direction was followed by the WSW (18.23 percent), WNW (16.39 percent), SSW (13.16 percent) and so on. In 2001, the total built-up area was 2850.3 hectare, out of this, most of the built-up area again lies in the ESE direction with 718.5 hectare which was 25.21 percent of the total built-up area and followed by the WSW (19.47 percent) and WNW (16.80 percent) directions. In 2011, 1027.67-hectare built-up areas fell in the ESE direction, which was 27.8 percent of the total built-up area. In 2011, 60 percent of the built-up area was located in three directions, namely, ESE, WSW, WNW. In 2021, out of total built-up area, 1639.44 hectare (23.78 percent) and 13.44.69 hectare (19.51percent) of built-up area were found in the ESE and WSW directions, respectively. In 2023, most of the built-up area was concentrated in the ESE direction, which was 1640 hectare or 23.46 percent of the total built-up area (**Fig. 2**). Throughout the study period, it has been noticed that the ESE direction is dominated by the concentration of built-up area. In the ESE direction, the share of built-up area to total built-up area increased till 2011, but after that, it slightly decreased. As previously discussed, the result shows that the maximum built-up area is concentrated in the ESE and WSW directions from Hisar city. The major reason for this concentration of built-up area is the location of census towns in these two particular directions. There are five census towns around the city, four of which lie in the ESE direction and one in the WSW direction (**Table-4**). The other reason for the built-up concentration in the ESE direction is the placement of the Army cantonment and passing of national highway 9 through this direction which connects the city to the nation's capital New Delhi. This national highway also plays a significant role in built-up expansion in WNW direction, resulting in third-highest concentration of built-up area in WNW direction.

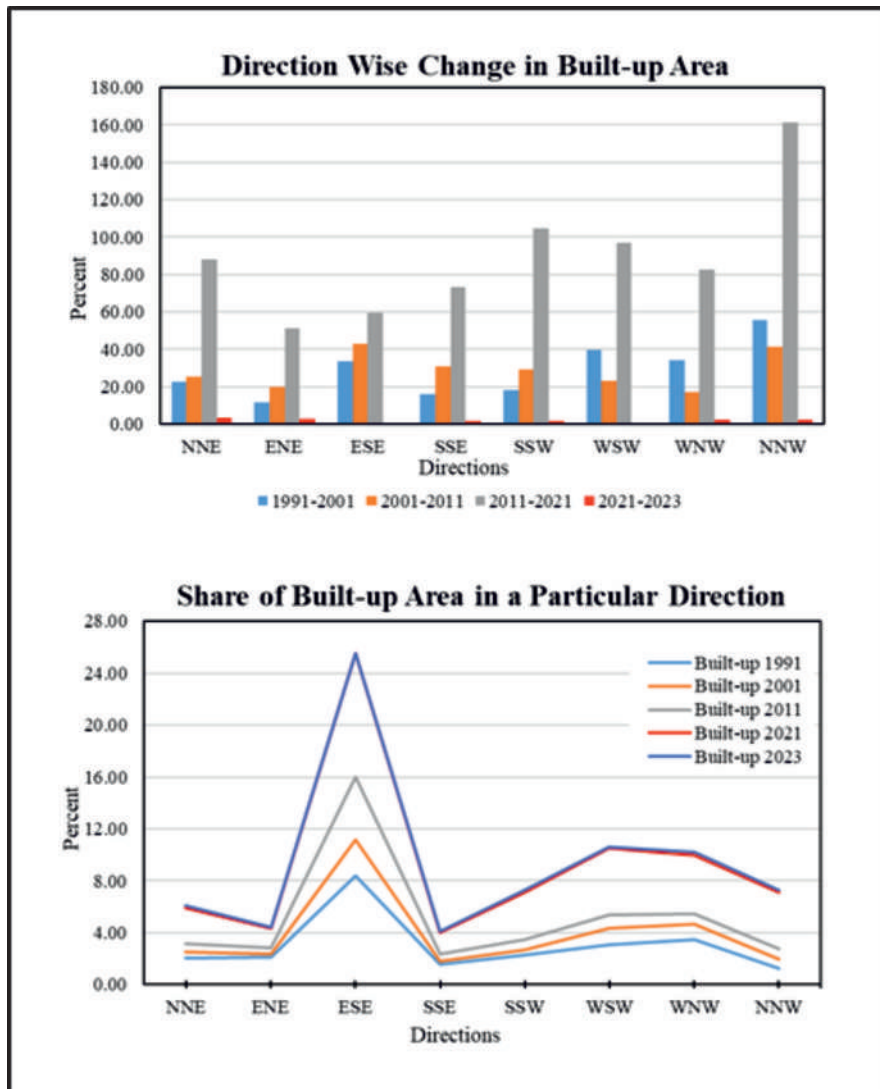


Fig. 2

Similar role is played by the national highway 52 in the WSW direction which connects the city to Jaipur (the capital of Rajasthan state).

Table-4: Directional Distribution of Built-up Area

Direction	1991 Built-up	2001 Built-up	2011 Built-up	2021 Built-up	2023 Built-up
NNE	202.86	249.03	311.49	585.18	605.07
ENE	123.3	137.34	164.61	248.58	255.78
ESE	538.56	718.56	1027.62	1639.44	1640.34
SSE	132.66	153.9	201.6	348.75	355.5
SSW	286.83	338.49	436.68	892.71	907.11
WSW	397.35	554.94	682.83	1344.69	1353.42
WNW	357.3	478.71	561.51	1023.84	1048.86
NNW	140.85	219.33	309.6	809.82	827.01

Source: Authors      Note: Uunit is in hectare.

It is observed that during the period of 1991–2001, the built-up in the NNW increased by 55.72 percent, which was the highest among all the directions. This increment in the built-up area was mainly due to the setup of police line area, government institution and growth in residential areas. The WSW direction recorded the second highest increase in built-up area followed by the WNW, ESE and so on. The ENE direction had the lowest increase in its built-up area, which is 11.39 percent. In the period of 2001–2011, the built-up area increased by 43 percent in the ESE direction and recorded the highest increase due to increase in the area under the residential buildings, business and industrial units and construction in army cantonment area, followed by the NNW (41.16 percent) and SSE (30.99 percent). The WNW direction got a minimum increase in built-up area of 17.30 percent. During the period of 2011–2021, the built-up area in the NNW direction recorded maximum growth (**Fig. 3**). The built-up area of the NNW direction increased by 161.57 percent, followed by the SSW (104.43 percent) and WSW (96.93 percent) direction. Direction ENE had a minimum increase in its built-up area of only 51 percent. The NNE direction saw the highest increase in the built-up area during 2021–2023; it recorded 3.40 percent increment in its built-up area. The result shows that in 1991, the ESE direction had the maximum proportion under the build-up area, which was 8.38 percent of the total area of the ESE direction. In all the other directions, built-up cover was less than 3.5 percent.

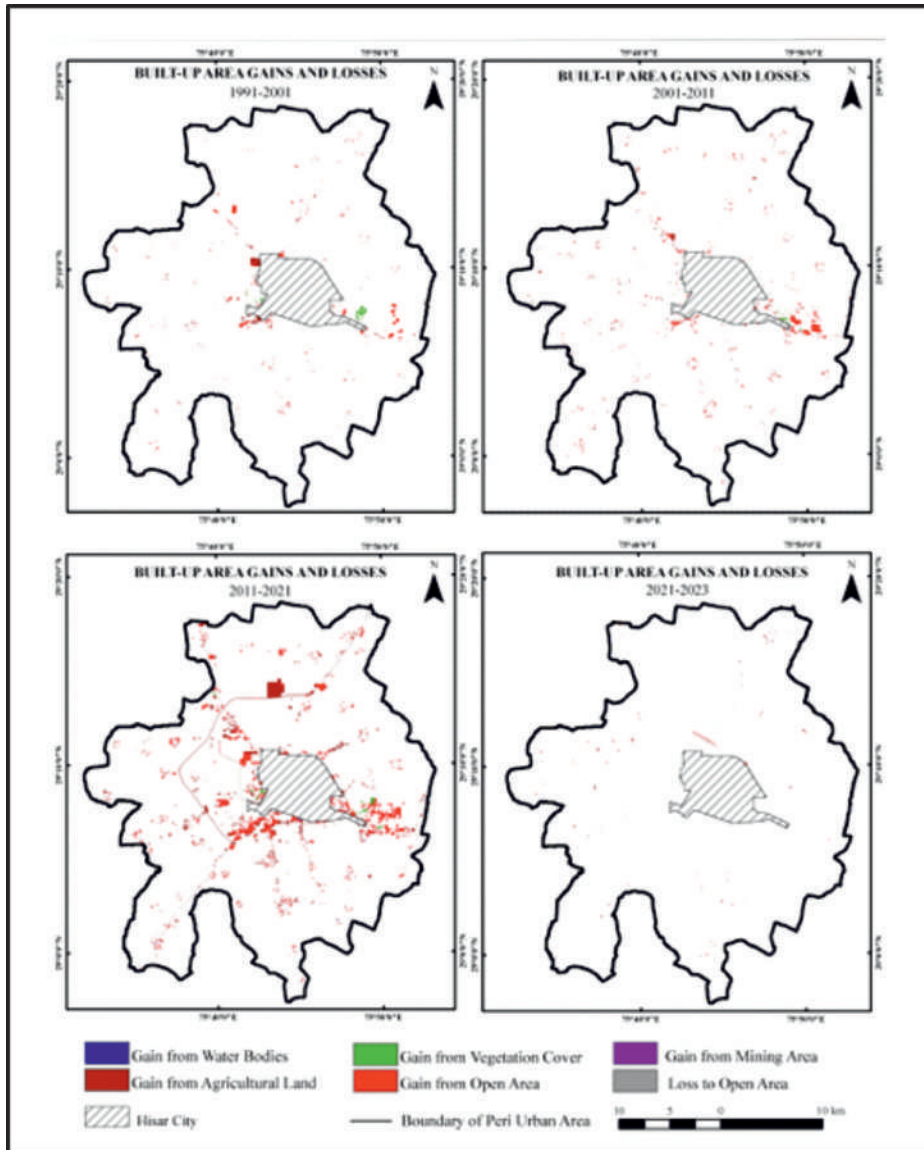


Fig. 3

In 2001, all directions got increments in their built-up area proportionate to their overall area of the respective direction. The ESE direction had maximum land under the built-up area which was 11.18 percent, followed by the WNW and WSW with 4.67 and 4.34 percent of built-up cover, respectively. The same pattern was repeated in 2011: ESE had the highest coverage, followed by the WNW and WSW directions. All other directions had less than 5 percent of the built-up area. In 2021, ESE again be on top, having 25.50 percent of the built-up area followed by the WSW and WNW directions with 10.51 and 10 percent of the built-up area, respectively. In 2023, the ESE direction had the maximum area under the built-up area, and the SSE direction had the minimum coverage of the built-up area.

### Gains and Losses to Built- up Area

The area under built-up has continuously increased on a daily basis by the different anthropogenic activities. As a result, the natural landscape has irreversibly and drastically changed into a built-up environment. The process of built-up expansion led to various serious problems, such as losses of arable land, water bodies, vegetation cover and open spaces. It also creates a problem of unauthorized and unorganized urban growth in peri-urban areas. **Table-5** shows the gains in built-up area from different classes. During the period of 1991–2001, the total increase in built-up area was 670.59 hectares; out of this, the major gains were open land (405 ha) and agricultural land (190.89 ha).

Table-5: Gains in Built-up Area from Different Classes

Classes	1991-2001	2001-2011	2011-2021	2021-2023
Water body	1.08	1.35	21.33	0
Agriculture	190.89	178.56	1303.38	79.74
Vegetation	70.65	29.07	75.51	0
Open land	405.18	633.42	1795.95	28.26
Mining	2.79	3.24	0.9	0

Source: Authors

The total area under the cover of built-up spaces increased by 845.64 hectares during 2001–2011, with major gains from open land (633.42 ha) and agricultural land (178.56 ha). The area of 3197.07 hectares was added in the built-up area of the peri-urban Hisar between 2011 and 2021. This addition to the built-up area is due to the losses of majorly open land (1795.95 ha) and agricultural land (1303.38 ha). The built-up also encroaches 21.33 hectares of land under the water bodies.

In the time period of 2021–2023, the built-up area gained 100 hectares of land, all of which came from agricultural land and open land. There were no losses in the built-up area during the period of 1991–2021. But it lost 7.92 hectares of land during 2021–2023. The built-up area (7.92 ha) was converted into open land as the land was acquired for the extension of the airport.

### **Magnitude of Built-up Expansion**

The built-up expansion intensity index (BEII) is utilized for calculating and analyzing the magnitude or speed of built-up expansion in the peri-urban area of Hisar city. The BEII is calculated for the classified images of different five dates (1991, 2001, 2011, 2021, 2023). The BEII is also used to analyze the direction-wise built-up expansion for all the considered years of the study. To study the direction wise magnitude of built-up expansion, the whole study area is divided into eight directions as discussed earlier. BEII results (**Fig. 4**) reveal that the value of BEII during 1991-2001 was 0.09 which indicates that the magnitude of built-up expansion was very low. But the value of BEII is 0.11 for the duration of 2001–2011. During this time period, the built-up expanded with little more magnitude than the previous time period. But during 2011–2021, the built-up increased at a low magnitude as per the standard of the BEII. But there was a sharp increase in the value of BEII and the value of BEII is 0.41. The period between 2011 and 2021 recorded the highest magnitude of built-up expansion among the different time frames of the study. The period of 2021–2023 recorded a very slow magnitude of built-up expansion with a 0.06 value of BEII. The BEII in different directions and different time frames indicated a wide range of values. In the time frame of 1991–2001, the ENE direction recorded the highest value of the BEII, which indicates the high speed of built-up expansion in this direction of all the other directions. On the standard scale, this is the only direction which had a low level of magnitude; all the other directions had a very low level of magnitude of built-up expansion. During 2001–2011, the ESE direction recorded the highest value of BEII, which is 0.48. It reflected that the built-up area significantly expanded in the ESE direction. On the standard scale, it stands at a low rate of built-up expansion, and in all other directions, built-up expansion was very low. For the period of 2011–2021, all the directions had recoded major expansion as compared to the previous time period. Among all the directions, ESE had the highest value of BEII which is 0.95, double as compared to the value of BEII in 2001–2011. In terms of magnitude of built-up expansion, ESE was followed by WSW, WNW, NNW and SSW directions, with BEII values of 0.52, 0.45, 0.42 and 0.36, respectively.

On the BEII's standard scale, the ESE direction had a medium speed of built-up expansion; WSW, WNW and NNW had a low level; and all the other directions had a very low magnitude of built-up expansion. During the year 2021-2023, the magnitude of built-up expansion appeared maximum in the WNW direction. The BEII value of the WNW direction is 0.12. On the standard scale, all directions have a very low rate of built-up expansion.

### Distribution of Built-up Expansion with the help of Entropy

Shannon entropy and relative entropy are used to analyze the distribution of built-up areas in the peri-urban Hisar. The Shannon entropy and relative entropy were calculated for each classified image in 1991, 2001, 2011, 2021 and 2023. To calculate entropy, the entire Hisar periurban area was subdivided into eight parts. The result depicted that the values of Shannon entropy (**Figure 7**) for all the years are very high and closer to the value of  $\log(n)$ , which is 2.08. It means the built-up area in the peri-urban area of Hisar is highly dispersed throughout the study period. The outcomes of relative entropy also conform the dispersed nature of the built-up area in peri urban of Hisar. The value of relative entropy for all time periods is also very high and closer to 1. The value of change in the relative entropy is negligible, which is  $\pm 0.01$ , shows that there is no such major change in the nature of built-up expansion and distribution with in peri-urban Hisar.

### Nature of Built-up Expansion

A wide variety of landscape indices are applied to analyze the configuration and composition of landscape patterns. In this study, five landscape metrics indices have been implemented to analyze the fragmentation in built-up area of peri urban Hisar. The indices are NP=Number of Patch, PD=Patch Density, ED=Edge density, MPS=Mean patch size and LPI=Largest Patch Index as shown in **Table-6**.

Table-6: Calculation of Landscape Indices

Year	NP	PD	ED	MPS	LPI
1991	165	0.21	9.33	13.21	0.44
2001	243	0.31	10.14	11.73	0.51
2011	291	0.37	11.10	12.70	1.12
2021	300	0.39	13.26	22.98	4.34
2023	346	0.45	13.69	20.21	4.36

Source: Authors

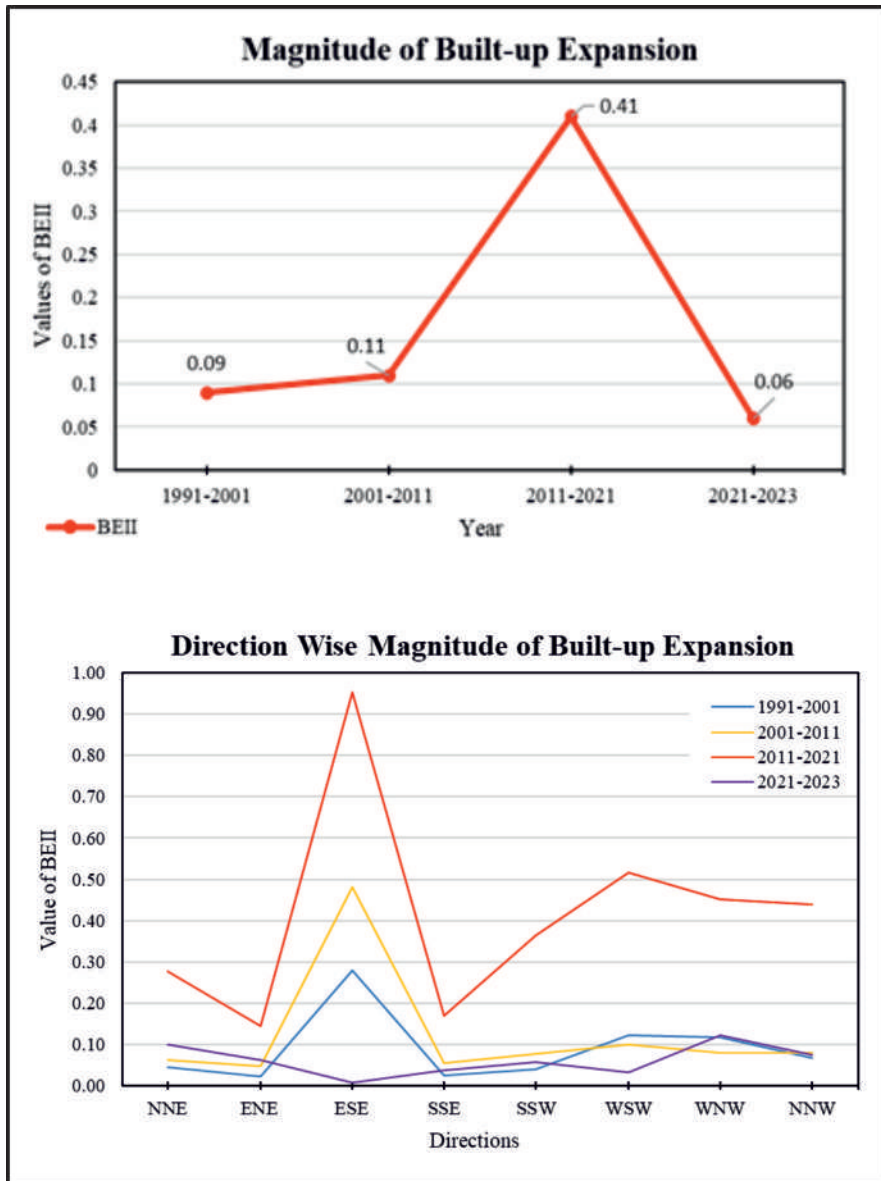


Fig. 4

### **Number of Patches (NP)**

This index simply provides the number of patches in particular class. As number of patches increases, it results in an increase in the fragmentation level. The NP has a positive relationship with the rate of fragmentation; as the patches increase, fragmentation increases, and vice versa (Abedini et al., 2020; Megahed et al., 2015; Leitao & Ahern, 2002). The result demonstrate that the number of built-up patches grew steadily during 1991 to 2023, from 165 to 346 patches (**Table-6**). During the period of 1991–2011, NP increased in large volume, but after that, it slowed down. This shows that there is continuous fragmentation in the built-up landscape in the study area. It demonstrates how anthropogenic activity has expanded beyond the existing boundaries of the built-up areas. The increasing number of patches also indicated that the urban development took place in leapfrog or spontaneous manners.

### **Patch Density (PD)**

In simple words, patch density index shows the number of patches per unit area. Patch density is an important indicator of fragmentation and has a positive relationship with the fragmentation. Patch density increases as the number of patches grows (Legarreta-Miranda et al., 2021; Shoyama & Braimoh, 2011). The analysis of patch density in study area, depicts that there is a consistent increase in patch density of built-up area over a period of time. In the period of 1991–2011, there was a high growth in the patch density but during the period of 2011–2021, it was at its minimum growth, and during 2021–2023, there was a spike in the patch density. It shows the fragmented nature of the urban area and its growth.

### **Edge Density (ED)**

Edge density also serves as a yardstick for fragmentation analysis. It also has a positive relation with fragmentation; fragmentation increases with the increment in the edge density (Legarreta-Miranda et al., 2021; Muhammed & Elias, 2021; Oertli et al., 2002). The result (**Table-6**) shows that edge density of built-up area continuously increases over a period of time. The edge density was 9.33 meters per hectare (m/ha) in 1991, and it rose to 13.39 m/ha in 2023 (**Fig. 5**). It indicates upsurge in the fragmentation process over the course of study. The fragmentation of the landscape has been confirmed by the increasing edge density collectively with the rising patch density (Legarreta-Miranda et al., 2021; Tolessa et al., 2016; Xue et al., 2016).

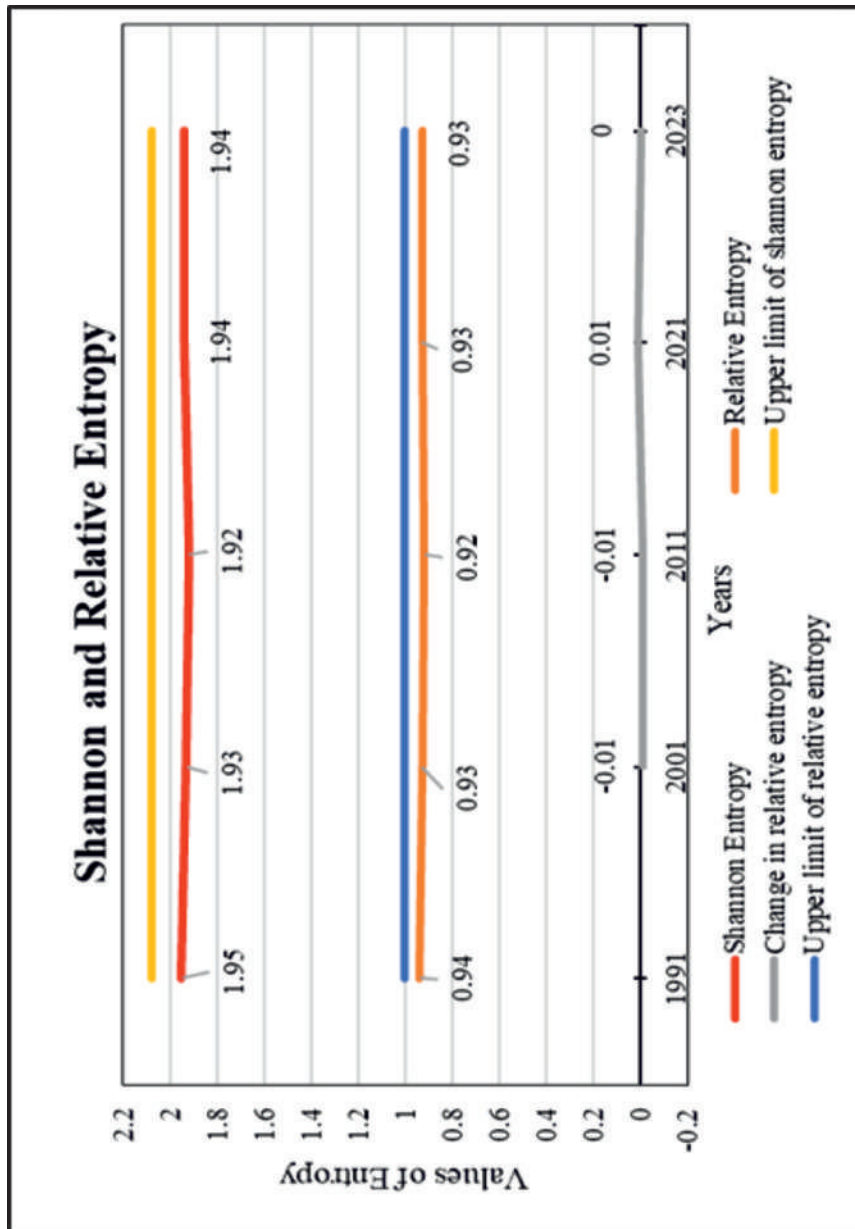


Fig. 5

### **Mean Patch Size (MPS)**

The mean patch size is defined as the arithmetic mean of the size of patches. In other words, it is the average size of a patch. Mean patch size has an inverse relationship with fragmentation and a positive relationship with the expansion and sprawl of the phenomenon (Legarreta-Miranda et al., 2021; Muhammed & Elias, 2021; Abedini et al., 2020). The analysis of mean patch size (**Table-6**) shows that the MPS of built-up decreased during 1991–2001 from 13.21 to 11.73 hectares. It shows expansion with fragmentation among the built-up area because the total area increases with decreasing MPS. MPS was 12.70 in 2011, which indicates an increase in MPS by 1 hectare as compared to 2001. There was a sharp rise in MPS during 2011–2021, which shows the expansion and sprawl of built-up areas. Again, the MPS decreased in 2023, which shows an increment in the fragmentation process. If we compare the MPS of 1991 and 2023, then the result indicated that the sprawl of the built-up area, and also indicated that the urban development in the peri urban area emerged in form of edge expansion. The new built-up area developed along the boundaries of the existing urban spaces.

### **Largest Patch Index (LPI)**

The Largest Patch Index represents the landscape's percentage comprised by the corresponding largest patch of a class. The Largest Patch Index has negative relationship with fragmentation and a positive relationship with the sprawl and expansion of the phenomena (Das & Angadi, 2021; Sun et al., 2015; Zhang et al., 2013). The result (**Table-6**) shows that the LPI of built-up was 0.44 percent in 1991 and increased to 4.36 percent in 2023. It indicated that there was continuous growth of the built-up area throughout the period. The overall result of LPI indicated continuous expansion of the built-up in peri urban area of the Hisar city. The overall result of the landscape metrics demonstrated that the built-up area in the peri urban area of the Hisar city is expanding continuously with the increment in the fragmentation of the landscape.

### **Conclusion**

This study mainly focuses on the analysis of built-up expansion. The result of the study indicated that the built-up area in the peri urban Hisar increased from 2179 hectare in 1991 to 6993 hectare in 2023. This expansion primarily occurs on the losses of agricultural land and open spaces. In the last 32 years, built-up area has been expended by more than threefold. In the peri urban Hisar,

a large share of the built-up area is concentrated in the ESE direction and the NNW direction witnessed the highest percentage increase in built-up area. The reasons for this concentration are location of census towns, army cantonment and national highway that passes from this direction. The study also found that the built-up area in the peri-urban Hisar is distributed in very high dispersed manner; on the other hand, the built-up area is expanded with the magnitude of slow to medium over the period of study as a whole and in different directions. It is also noted that the city is expanded with the increment in the fragmentation level. This shows that newly built-up areas are developed in the periphery of the city but away from the city boundary. The major reason for the built-up expansion in the peri-urban area of Hisar is increasing population, migration, and economic development. During the study period, several new infrastructures had developed in the peri-urban Hisar, for example, residential colonies, educational institutes, recreational centers, factories, warehouses, widening of national highways and construction of new roads, upgradation of an international cargo airport, etc. This analysis can be utilized to improve an array of policies, stimulate sustainable development, and contribute to scientific decisions.

## References

- Abedini A, Khalili A, Asadi N. Urban sprawl evaluation using landscape metrics and black-and-white hypothesis (case study: Urmia City). *Journal of the Indian Society of Remote Sensing* 2020; 48: 1021-1034. <https://doi.org/10.1007/s12524-020-01132-5>
- Alsharif A. A, Pradhan B, Shafri H. Z. M, Mansor S. Quantitative analysis of urban sprawl in Tripoli using Pearson's Chi-Square statistics and urban expansion intensity index. *IOP Conference Series: Earth and Environmental Science* 2014; 20: 012006. <https://doi.org/10.1088/1755-1315/20/1/012006>
- Alsharif A. A, Pradhan B. Urban sprawl analysis of Tripoli Metropolitan city (Libya) using remote sensing data and multivariate logistic regression model. *Journal of the Indian Society of Remote Sensing* 2014; 42: 149-163. <https://doi.org/10.1007/s12524-013-0299-7>
- Chandrasekhar S, Sharma A. Urbanization and spatial patterns of internal migration in India. *Spatial demography* 2015; 3: 63-89. <https://doi.org/10.1007/s40980-015-0006-0>
- Das S, & Angadi D P. Assessment of urban sprawl using landscape metrics and Shannon's entropy model approach in town level of Barrackpore sub-divisional region, India. *Modeling Earth Systems and Environment* 2021; 7: 1071-1095. <https://doi.org/10.1007/s40808-020-00990-9>
- Dutta D, Rahman A, Paul S. K, Kundu A. Estimating urban growth in peri-urban areas and its interrelationships with built-up density using earth observation datasets. *The Annals of Regional Science* 2020; 65: 67-82. <https://doi.org/10.1007/s00168-020-00974-8>
- Jiang L, O'Neill B. C. Determinants of urban growth during demographic and mobility transitions: Evidence from India, Mexico, and the US. *Population and development review* 2018; 44 (2): 363-389. <https://doi.org/10.1111/padr.12150>

- Legarreta-Miranda C. K, Prieto-Amparan J. A, Villarreal-Guerrero F, Morales-Nieto C. R, Pinedo-Alvarez A. Long-term land-use/land-cover change increased the landscape heterogeneity of a fragmented temperate forest in Mexico. *Forests* 2021; 12(8): 1099. <https://doi.org/10.3390/f12081099>
- Leitao A. B, Ahern J. Applying landscape ecological concepts and metrics in sustainable landscape planning. *Landscape and urban planning* 2002; 59(2): 65-93. [https://doi.org/10.1016/S0169-2046\(02\)00005-1](https://doi.org/10.1016/S0169-2046(02)00005-1)
- Li D, Huang Y, Qiao B, Yan X, He W. The Research on Land-Use Change and Ecological Environment Effect of Urban Landscape in China. *International Journal of Geosciences* 2016; 7(7): 956-961. <http://dx.doi.org/10.4236/ijg.2016.77072>
- McFarland P. The Peri-urban land-use planning tangle: An Australian perspective. *International Planning Studies* 2015; 20(3): 161-179. <https://doi.org/10.1080/13563475.2014.965250>
- McGarigal K. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure (Vol. 351). US Department of Agriculture, Forest Service, Pacific Northwest Research Station; 1995.
- Megahed Y, Cabral P, Silva J, Caetano M. Land cover mapping analysis and urban growth modelling using remote sensing techniques in Greater Cairo Region—Egypt. *ISPRS International Journal of Geo-Information* 2015; 4(3): 1750-1769. <https://doi.org/10.3390/ijgi4031750>.
- Mithun S, Chattopadhyay S, Bhatta B. Analyzing urban dynamics of metropolitan Kolkata, India by using landscape metrics. *Papers in Applied Geography* 2016; 2(3): 284-297. <https://doi.org/10.1080/23754931.2016.1148069>
- Muhammed A, Elias E. Class and landscape level habitat fragmentation analysis in the Bale mountains national park, southeastern Ethiopia. *Heliyon* 2021; 7(7): e07642 <https://doi.org/10.1016/j.heliyon.2021.e07642>
- Oertli B, Joye D. A, Castella E, Juge R, Cambin D, Lachavanne J. B. Does size matter? The relationship between pond area and biodiversity. *Biological conservation* 2002; 104(1): 59-70. [https://doi.org/10.1016/S0006-3207\(01\)00154-9](https://doi.org/10.1016/S0006-3207(01)00154-9)
- Rahman A, Aggarwal S.P, Netzband M, Fazal S. Monitoring urban sprawl using remote sensing and GIS techniques of a fast growing urban centre, India. *IEEE Journal of selected topics in applied earth observations and remote sensing* 2011; 4(1): 56-64. <https://doi.org/10.1109/JSTARS.2010.2084072>
- Ren, P., Gan, S., Yuan, X., Zong, H., & Xie, X. (2013). Spatial Expansion and sprawl quantitative analysis of mountain city built-up area. In F. Bian, Y. Xie, X. Cui & Y. Zeng. *Geo-informatics in resource management and sustainable ecosystem*. Springer. 2013:166-176. [https://doi.org/10.1007/978-3-642-45025-9\\_19](https://doi.org/10.1007/978-3-642-45025-9_19)
- Roy B, Kasemi N. Monitoring urban growth dynamics using remote sensing and GIS techniques of Raiganj Urban Agglomeration, India. *The Egyptian Journal of Remote Sensing and Space Science* 2021; 24(2): 221-230. <https://doi.org/10.1016/j.ejrs.2021.02.001>
- Sahana M, Hong H, Sajjad H. Analyzing urban spatial patterns and trend of urban growth using urban sprawl matrix: A study on Kolkata urban agglomeration, India. *Science of the Total Environment* 2018; 628: 1557-1566. <https://doi.org/10.1016/j.scitotenv.2018.02.170>
- Shaw R, Das A. Identifying peri-urban growth in small and medium towns using GIS and remote sensing technique: A case study of English Bazar Urban Agglomeration, West Bengal, India. *The Egyptian Journal of Remote Sensing and Space Science* 2018; 21(2): 159-172. <https://doi.org/10.1016/j.ejrs.2017.01.002>
- Shoyama K, Braimoh A. K. Analyzing about sixty years of land-cover change and associated landscape fragmentation in Shiretoko Peninsula, Northern Japan. *Landscape and Urban Planning* 2011; 101(1): 22-29. <https://doi.org/10.1016/j.landurbplan.2010.12.016>

- Sinha S. K. Causes of urban sprawl: a comparative study of developed and developing world cities. *International Journal of Multidisciplinary* 2018; 3(9): 5-9. <https://doi.org/10.5281/zenodo.1409035>
- Sudhira H. S, Ramachandra T. V, Jagadish K. S. Urban sprawl: metrics, dynamics and modelling using GIS. *International Journal of Applied Earth Observation and Geoinformation* 2004; 5(1): 29-39. <https://doi.org/10.1016/j.jag.2003.08.002>
- Sun Y, Zhao S, Qu W. Quantifying spatiotemporal patterns of urban expansion in three capital cities in Northeast China over the past three decades using satellite data sets. *Environmental Earth Sciences* 2015; 73: 7221-7235. <https://doi.org/10.1007/s12665-014-3901-6>
- Sur U, Singh P. Assessment of Landscape Change of Lesser Himalayan Road Corridor of Uttarakhand, India. *Journal of Landscape Ecology* 2020; 13(3): 1-22. <https://doi.org/10.2478/jlecol-2020-0014>
- Tolessa T, Senbeta F, Kidane M. Landscape composition and configuration in the central highlands of Ethiopia. *Ecology and evolution* 2016; 6(20): 7409-7421. <https://doi.org/10.1002/ece3.2477>
- Turner B, Clark W. C, Kates R. W, Richards J. F, Mathews J. T, Meyer W. B. *The Earth as transformed by human action: global change and regional changes in the biosphere over the past 300 years*. United States of America: Cambridge University Press; 1990.
- Weller R. H, Macisco J. J, Martine G. R. The relative importance of the components of urban growth in Latin America. *Demography* 1971; 8(2): 225-232. <https://doi.org/10.2307/2060611>
- Wilmoth M. J, Menozzi M. C, Bassarsky M. L. Why population growth matters for sustainable development. United Nations Department of Economic and Social Affairs; 2022. <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/PB-130-FINAL.pdf>
- Xue X, Hualin X, Yuanhua F. Spatiotemporal patterns and drivers of forest change from 1985–2000 in the Beijing-Tianjin-Hebei region of China. *Journal of Resources and Ecology* 2016; 7(4): 301-308. <https://doi.org/10.5814/j.issn.1674-764x.2016.04.009>
- Yeh A. G. O, Li X. Measurement and monitoring of urban sprawl in a rapidly growing region using entropy. *Photogrammetric engineering and remote sensing* 2001; 67: 83-90. [https://www.asprs.org/wp-content/uploads/pers/2001journal/january/2001\\_jan\\_83-90.pdf](https://www.asprs.org/wp-content/uploads/pers/2001journal/january/2001_jan_83-90.pdf)
- Zhang S, York A.M, Boone C. G, Shrestha M. Methodological advances in the spatial analysis of land fragmentation. *The Professional Geographer* 2013; 65(3): 512-526. <https://doi.org/10.1080/00330124.2012.700501>

--Rahul  
Research scholar  
Department of Geography  
Panjab University  
Chandigarh (Panjab)

--Ravinder Kaur  
Professor  
Department of Geography  
Panjab University  
Chandigarh (Panjab)



## **REGIONAL AND TEMPORAL TREND OF CHILD POPULATION SEX RATIO IN KARNATAKA**

Dr. Saritha K. and Dr. S. Srikanta Prasad

### **Abstract**

Children are often regarded as the heart of our homes, the backbone of our economy, and the socio-economic security for the future. Unfortunately, in our study area also there has been a concerning trend over the past fifty years where a significant proportion of the child population has been disappearing from our demographic structure. According to census data, the percentage of children in the total population was 42.4% in 1971, which decreased to 26.2% by 2011, representing a decline of 16.2%. This decline is primarily attributed to the decreasing trend in fertility rates. The diminishing proportion of children in the total population has profound socio-economic and cultural implications, particularly impacting the balance between male and female child populations and leading to issues such as sex ratio in our study area. Female feticide remains a major factor contributing to this imbalance. Population sex ratio, defined as the number of females per 1000 males, is a critical indicator of sex composition. In Karnataka, the Child Sex Ratio (CSR) has shown a dramatic decline over the past five decades, with slight regional variations. This paper focuses on analysing the temporal trends and regional patterns in the growth of child population and child sex ratio in Karnataka. Data from 1971 to 2011 at the district level was collected, along with Total Fertility Rate (TFR) data, to calculate decennial growth rates, changes in child population numbers, and child sex ratios using MS Excel. Simple cartogram methods were employed to prepare data tables, trend lines, and bar graphs. These techniques are instrumental in comprehending the temporal trends in the growth and sex ratio of the child population across various regions of Karnataka. The findings reveal that over the last fifty years, there has been a significant decrease in the proportion of children in the total population, resulting in a widening gap between male and female numbers. In 1971, the child ratio was 989, which decreased to 947 by 2011, regional disparities within Karnataka. Furthermore, using the Pearson correlation method, this study examined the relationship between Child Population Sex

Ratio (CPSR) and Total Fertility Rate (TFR) at the regional level in Karnataka. The analysis indicated a negative relationship across all regions, suggesting that higher fertility rates corresponded with lower imbalances between male and female child populations, whereas lower fertility rates were associated with greater gender disparities among children.

### **Introduction**

The population sex ratio is a fundamental demographic measure of Sex composition, also known as the gender ratio. Globally, it typically denotes the number of males per 100 females. However, in India, including our study area, this ratio is presented as the number of females per 1000 males according to census data. This distinction arises because developed countries often exhibit a surplus of females, whereas developing nations like India tend to have more males. The benchmark of 1000 represents a balance point in this measure: ratios above 1000 indicate a surplus of females, while ratios below 1000 indicate a surplus of males. In this paper, the sex ratio is categorized into four types: General Population Sex Ratio, Child Population Sex Ratio, Adult Population Sex Ratio, and Elderly Population Sex Ratio. The General Population Sex Ratio: in Karnataka, it was a slight increase from 964 in 1991 to 973 in 2011, reflects a rise of 9 points over two decades. The Child Population Sex Ratio, which measures females below 14 years per 1000 males in the same age group, saw a decline in Karnataka from 989 in 1971 to 947 in 2011, indicating significant demographic shifts. The Adult Population Sex Ratio, focusing on the 15 to 59 age group, showed a gradual increase from 954 in 1981 to 965 in 2011. Conversely, the Elderly Population Sex Ratio, highlighting individuals aged 60 and above, demonstrated a positive sex ratio with females outnumbering males, rising from 988 in 1991 to 1105 in 2011. Among these categories, the General, Child, and Adult Population Sex Ratios exhibit negative trends, signifying imbalances favouring male populations. In contrast, the Elderly Population Sex Ratio reflects a positive trend, indicating a female surplus. Despite efforts to mitigate disparities among the General, Child, and Adult sex ratios over decades, the Child Population Sex Ratio continues to decline unfavourably, influenced by socio-economic and demographic factors.

Therefore, this paper focuses on examining the temporal trends and regional patterns of the Child Population Sex Ratio in Karnataka. According to Section 2(k) of the Juvenile Justice Act 2015, the term 'child' refers to any person below the age of 18 years. In the context of this study, the term 'child' encompasses different age

groups such as 0-6 years, 0-10 years, 0-14 years, and 0-18 years. Specifically, for this research, 'child' is defined as individuals aged between 0-14 years, excluding those above 14 years, as most studies focus on this particular age range. Children aged 15-18 years are categorized under the pre-adolescent age group. The present study aims to analyse the temporal trends and regional patterns in the population sex ratio of children aged 0-14 years in Karnataka.

### **Study Region**

Karnataka, a southern state in India, is renowned for its advancements in various fields. Geographically, it stretches from latitude 110 31' to 180 45' North and longitude 740 12' to 780 40' East, covering a total area of 191,791 square kilometres. As per the 2011 census it has 30 district. The state is divided into three regions based on geographical location, latitudinal distribution, relief features, cultural aspects, and other factors: Northern Karnataka Region (NKR), Southern Karnataka Region (SKR), and Coastal Karnataka Region (CKR). Northern Karnataka Region (NKR) includes districts such as Bagalkot, Belgaum, Bellary, Bidar, Bijapur, Dharwad, Gadag, Gulbarga, Haveri, Koppal, Raichur, and Yadgir. Southern Karnataka Region (SKR) comprises Bangalore, Bangalore Rural, Chamarajanagar, Chikkaballapura, Chikmagalur, Chitradurga, Davanagere, Hassan, Kodagu, Kolar, Mandya, Mysore, Ramanagara, Shimoga, and Tumkur districts. Coastal Karnataka Region (CKR) consists of Dakshina Kannada, Udupi, and Uttara Kannada districts. According to the 2011 census data, Karnataka had a total child population of 15,973,953, comprising 8,207,539 males and 7,766,414 females, with variations observed across these regions.

### **Objectives**

- (1) To comprehend the temporal trends and regional patterns in the growth of the child population in Karnataka.
- (2) To investigate the temporal trends and regional patterns of the child population sex ratio in Karnataka.

### **Database and Methodology**

This study relies on secondary sources of information, gathering data spanning the last forty years (1971 to 2011), including age-specific data and the Total Fertility Rate (TFR) of Karnataka at the district level from sources such as the Census of India, Sample Registration System (SRS), journals, reports, projects,

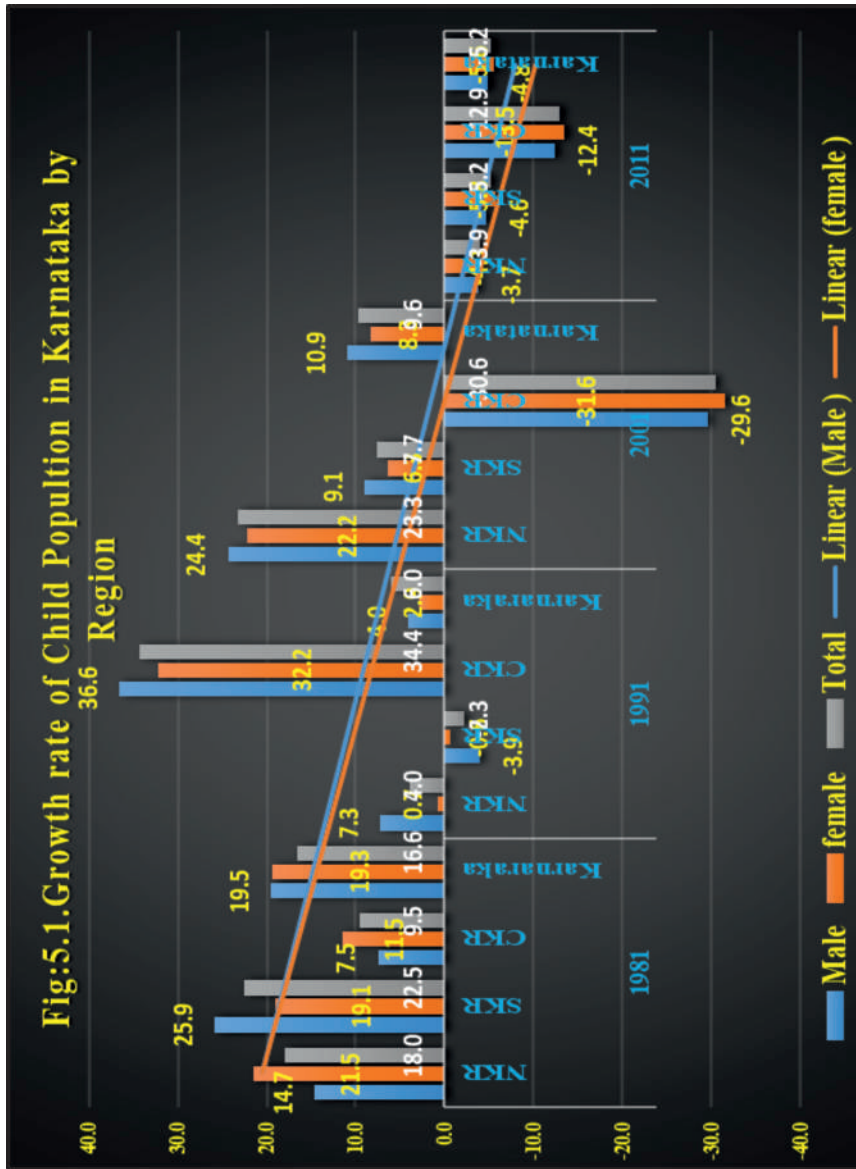


Fig. 1

books, and other publications. The methodology employs two statistical techniques: Descriptive methods, including the calculation of growth rates and sex ratio, to analyse the growth rate and child sex ratio of the population below 14 years of age in Karnataka at the regional level. Inferential methods, such as Pearson correlation analysis, to understand the relationship between the child population sex ratio and the Total Fertility Rate across different regions of Karnataka.

## **Results and Discussion**

### **Temporal Trend and Regional Patterns in Child Population Growth (1971 to 2001)**

In Karnataka, all regions exhibited an increasing trend in the total child population in terms of numbers from 1971 to 2001, followed by a subsequent decrease. However, the added number of child populations to the total child population decreased every decade. For instance, between 1971 and 1981, the added number was 2,413,308; from 1981 to 1991, it reduced to 516,039; and between 1991 and 2001, it was 1,481,649. From 2001 to 2011, there was a decline of -871,648 children. This trend was consistent across all regions (**Table-1**). The growth rate of the child population was primarily influenced by the decennial addition of children. This addition progressively increased until 2001 but turned negative thereafter. The growth rate decreased from 16.6% in 1981 to 6% in 1991, rose to 9.6% in 2001, and then declined to -5.2% in 2011. The primary reasons for this negative growth rate and declining addition of children are an increase in the female mean age at marriage and a decrease in the Total Fertility Rate. Let's analyse these factors in detail.

### **Mean Age at Marriage**

The reproductive health and well-being of women are influenced by various factors including the age at first marriage, menarche, first birth, and menopause. In Karnataka, the mean age at marriage for women saw a significant increase over the past five decades. Specifically, it was recorded as 16.0 years in 1971 and 16.9 years in 1981, escalating to 19.1 years in 2002-04, and continuing to rise to 22.8 years by 2020, according to the SRS 2020 report. This trend indicates an overall increase of 6.8 years in the mean age at marriage of women from 1971 to 2020. Over the past fifty years, the mean age at marriage of females in Karnataka has shown a steady increase. In 1971, the average age at marriage was 16.0 years,

Table-1: Region wise Temporal Trend of Child population in Karnataka

Decades	Regions	Regions			Total	Decennial changes in numbers	Growth Rate (0-14 years)		
		Male child	Female child	Total			Male child	Female child	Total
1971	NKR	2580272	2499992	5080264	-	-	-	-	-
	SKR	3067697	3087913	6155610	-	-	-	-	-
	CKR	603599	595132	1198731	-	-	-	-	-
	Karnataka	6251568	6183037	12434605	-	-	-	-	-
1981	NKR	2959260	3036350	5995610	(1971- 81)	915346	14.7	21.5	18.0
	SKR	3861740	3678008	7539748	1384138	25.9	19.1	22.5	
	CKR	648884	663671	1312555	113824	7.5	11.5	9.5	
	Karnataka	7469884	7378029	14499985	2413308	19.5	19.3	16.6	
1991	NKR	3175547	3056898	6232445	(1981 to 91)	236835	7.3	0.7	4.0
	SKR	3710420	3657559	7367979	-171769	-3.9	-0.6	-2.3	
	CKR	886096	877432	1763528	450973	36.6	32.2	34.4	
	Karnataka	7772063	7591889	15363952	516039	4.0	2.9	6.0	
2001	NKR	3949757	3737011	7686768	(1991-01)	1454323	24.4	22.2	23.3
	SKR	4046274	3888535	7934809	566830	9.1	6.3	7.7	
	CKR	624155	599869	1224024	-539504	-29.6	-31.6	-30.6	
	Karnataka	8620186	8225415	16845601	1481649	10.9	8.3	9.6	
2011	NKR	3802000	3582373	7384373	-302395	-3.7	-4.1	-3.9	
	SKR	3858858	3664931	7523789	-411020	-4.6	-5.8	-5.2	
	CKR	546681	519110	1065791	-158233	-12.4	-13.5	-12.9	
	Karnataka	8207539	7766414	15973953	-871648	-4.8	-5.6	-5.2	

Source: Compiled by the authors using census data Note: population (in %)

Index: NKR\_ Northern Karnataka Region, SKR\_ Southern Karnataka Region, CKR\_ Coastal Karnataka Region

which rose to 22.8 years by 2020, marking an increase of 6.8 years over this period. The mean age at marriage of women is crucial as it inversely impacts their reproductive period duration. A lower mean age at marriage indicates a longer reproductive span, whereas a higher mean age at marriage shortens it. Therefore, the rise in the mean age at marriage of females directly correlates with a decrease in their reproductive period. Globally, the reproductive age for women is recognized by the World Health Organization as 15 to 49 years, while in India, it spans from 15 to 44 years. Based on the aforementioned data on the mean age at marriage of females, the total reproductive period for women in our study area was 28 years in 1971, but it decreased to 22.8 years by 2020, reflecting a reduction of 6.8 years over five decades. The decline in the length of the reproductive period significantly contributes to the decreasing growth of the child population directly and indirectly affects the declining child sex ratio. This is influenced by a trend where many working individuals choose not to have a second child if the first child is a boy, whereas they opt for a second child if the first child is a girl. From 1971 to 2011, nearly 50 percent of children have disappeared from our age structure in Karnataka. In 1971, children constituted 42.2% of the total population, which decreased to 26.2% by 2011 (Table 5.2). Another crucial determinant of the child population's composition within the total population is the Total Fertility Rate (TFR).

### **Total Fertility Rate**

The Total Fertility Rate (TFR) refers to the average number of children a woman would bear during her reproductive years. In 1981, the TFR in Karnataka was notably higher, with an average of 4.7 children per married woman. By 2011, this rate had decreased to 2.0 children, and further dropped to 1.6 children by 2021, marking a decline of approximately 3.1 children per woman over five decades, with regional variations. This study classifies the TFR levels in Karnataka based on the United Nations classification method, with modifications. The classifications include: High fertility level (above 4 children per woman). Medium fertility level (above 3 and below 4 children per woman). Low fertility level (above 2 and below 3 children per woman). Replacement level fertility (2.1 children per woman). Below replacement level (less than 2 children per woman). Very low or ultra-low fertility (less than 1.3 children per woman). From 1981 to 2011, all regions in Karnataka experienced a decline in TFR, reflecting regional variations (**Table-2**). Northern Karnataka Region (NKR) maintained high fertility levels until 1991,

transitioning to medium fertility in 2001 and low fertility by 2011, with 2.70 children per woman. In contrast, Southern Karnataka Region (SKR) and Coastal Karnataka Region (CKR) entered medium and low fertility levels earlier, reaching below replacement levels by 2011, with less than 1.70 TFR.

Table-2: Regional and Temporal Trend of Child Population

Decades	Regions	% of child population to Total child population	On an average each district contribution of Child population (%)	% of Child population in Total Population
1981	NKR	40.4	3.37	41.1
	SKR	50.8	3.39	38.9
	CKR	8.8	2.95	38.2
	Karnataka	100.0	3.33	39.5
1991	NKR	40.6	3.38	39.4
	SKR	48.0	3.20	34.3
	CKR	11.5	3.81	33.6
	Karnataka	100.0	3.33	36
2001	NKR	45.6	3.80	36.2
	SKR	47.1	3.14	29.4
	CKR	7.3	2.42	28
	Karnataka	100.0	3.33	31.9
2011	NKR	46.0	3.83	30.4
	SKR	47.3	3.15	23.9
	CKR	6.7	2.23	22.5
	Karnataka	100.0	3.33	26.2

Source: Compiled by authors using Census data

Note : In 1971 the percent of child population in Total population NKR\_ 42.9%, SKR\_42.4%, CKR\_43% and Karnataka \_42.4%

Index: NKR\_ Northern Karnataka Region, SKR\_ Southern Karnataka Region, CKR\_ Coastal Karnataka Region

The regional variation in TFR directly impacts the percentage share of child population within the total child population of each region. NKR, for instance, saw an increase in its share from 40.4% in 1981 to 46% in 2011, whereas SKR and CKR experienced declines over the same period. In SKR, the share decreased from 50.8% in 1981 to 47.1% in 2001, with a slight increase to .2% by 2011. In CKR, the share decreased from 8.8% in 1981 to 6.7% in 2011 (Table-5). From 1981 to 2011, the average percentage share of the child population in each district of North Karnataka (NKR) showed an increasing trend, while the trend was opposite in South Karnataka (SKR) and Coastal Karnataka (CKR). In 1981, the share of the child population in each district of NKR was 3.37%, which increased to 3.38% in 1991, 3.80% in 2001, and 3.83% in 2011. Conversely, in SKR, the share of the child population in each district decreased from 3.39% in 1981 to 3.20% in 1991, further declining to 3.14% in 2001 and nearly constant at 3.15% in 2011. In CKR, the share of the child population was 2.95% in 1981, which decreased to 2.42% in 2001 and further to 2.23% in 2011. Overall, in our study area, the Total Fertility Rate (TFR) remained high until 1991 but subsequently experienced a rapid decline. Consequently, the total number of child population also witnessed a significant decrease, falling from 16,845,601 in 2001 to 15,973,953 in 2011, marking a decline of -871,648 within a decade. This declining trend was observed uniformly across all regions.

### **Temporal Trend and Regional Patterns in Child Population Sex Ratio in Karnataka**

In Karnataka, there is an intriguing trend where the total population continues to increase from decade to decade, but the child population (aged up to 14 years) shows an opposite trajectory, declining in numbers. This phenomenon directly impacts both the general population sex ratio and the child population sex ratio in our study area. Because it is influenced by a trend where many working individuals choose not to have a second child if the first child is a boy, whereas they opt for a second child if the first child is a girl. The general population sex ratio in Karnataka was positive, reaching 964 in 2001 and increasing to 973 in 2011, marking the highest ratio since 1921 (Table-3). However, during the same period, the child sex ratio declined significantly from 987 in 1981 to 947 in 2011, reflecting a decrease of 40 points. Interestingly, this trend is not unique to our study area. Despite women generally having a longer life expectancy than men, the child sex ratio consistently favours male children over female children (**Fig. 2**).

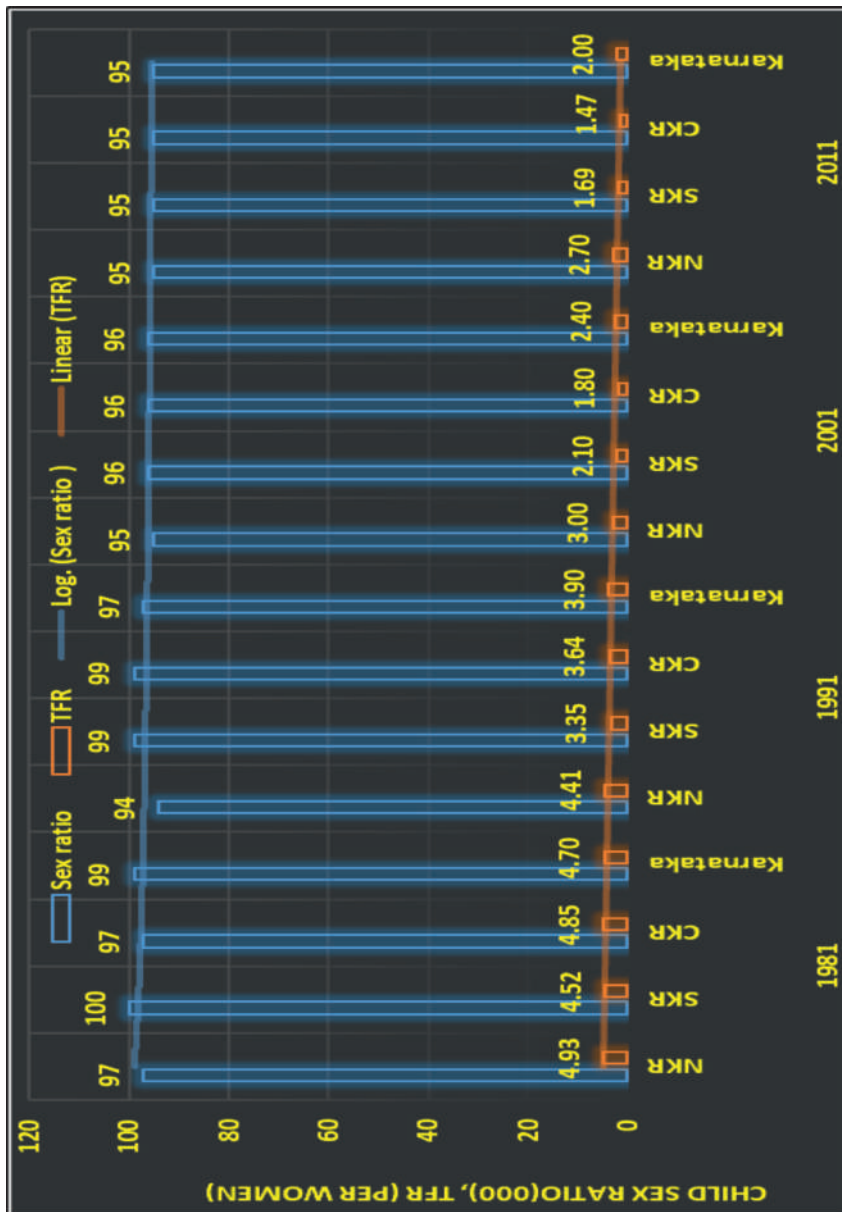


Fig. 2

Table-3: Relationship between Child Sex Ratio and TFR in Karnataka (1981 to 2011)

Decades	Regions	Sex Ratio	TFR in Percent	Pearson Correlation
1981	NKR	974	4.93	-0.12
	SKR	1005	4.52	0.72
	CKR	973	4.85	-1.00
	Karnataka	987	4.70	-0.24
1991	NKR	944	4.41	-0.29
	SKR	988	3.35	-0.44
	CKR	987	3.64	-1.00
	Karnataka	971	3.90	-0.71
2001	NKR	951	3.00	-0.04
	SKR	963	2.10	-0.29
	CKR	962	1.80	-0.97
	Karnataka	958	2.40	-0.52
2011	NKR	947	2.70	0.02
	SKR	951	1.69	-0.39
	CKR	952	1.47	-0.96
	Karnataka	947	2.00	-0.26

Source: Compiled by Authors by use of Census and TFR data

In Karnataka, all regions exhibit a declining trend in Child Sex Ratio (CSR) from 1981 to 2011, with slight regional variations. In 1981, there were 987 female children per 1000 male children, which decreased to 971 in 1991 (a decline of 16 children), further decreasing to 958 in 2001 (a decline of 13 children), and to 947 in 2011 (an additional decline of 11 children). This trend is reflected in all the regions of Karnataka. In North Karnataka (NKR), the Child Sex Ratio was 974 in 1981, declining sharply to 944 in 1991 (a decrease of 30 children), followed by a decrease to 951 in 2001, and 947 in 2011 (a decrease of 4 children over the decade). Similar patterns were observed in Southern Karnataka Region (SKR) and Coastal Karnataka Region (CKR) as reflected in Table-3. Several factors contribute to this declining trend in the Child Sex Ratio is as below:

- (a) **Biological Factors:** According to biological laws, the number of male births typically exceeds that of female births due to natural imbalances at conception. This ratio is estimated to be around 125 to 135 males per 100 female conceptions.
- (b) **Decline in Share of Child Population to Total Population:** As discussed earlier (Section 5.1), the declining fertility rates and increasing mean age at marriage among women have reduced the proportion of children in the total population. This demographic shift has implications for the child sex ratio.
- (c) **Female Foeticide:** Perhaps the most significant factor contributing to the negative child sex ratio in Karnataka is female foeticide, which refers to the abortion of female fetuses. This practice is driven by socio-economic and cultural factors deeply rooted in patriarchal norms. In many parts of India, including Karnataka, there exists a historical bias against girls, viewing them as liabilities due to dowry obligations and future family responsibilities. Factors such as preference for sons to carry on the family name, economic burden associated with daughters (e.g., dowry), and societal beliefs perpetuate the practice of female foeticide. Economic instability and poverty exacerbate this issue, as families may perceive daughters as additional financial burdens. Advances in science and technology have made sex determination easier, leading to an increase in selective abortions based on the sex of the foetus. To comprehend the regional variations in the child sex ratio, it is essential to explore the correlation between the Child Population Sex Ratio (CPSR) and the Total Fertility Rate (TFR). This correlation analysis can provide insights into how fertility patterns influence the gender dynamics of the child population across different regions of Karnataka.

In Karnataka, all regions exhibit a negative correlation between sex ratio and Total Fertility Rate (TFR). Higher fertility rates are associated with a lower imbalance between male and female child populations, whereas lower fertility rates lead to a higher imbalance favouring male children. At the state level, the sex ratio and TFR showed a negative correlation of -0.24 in 1981, which was the strongest negative correlation compared to -0.26 in 2011. This indicates that in 1981, the imbalance between male and female child populations was only 13 points, but this gap widened to 53 points by 2011. This trend is consistent across all regions of Karnataka.

## **Conclusion**

Sex ratio is a fundamental demographic indicator essential for analysing age structure, gender balance, fertility levels, and mortality rates. It serves as a crucial tool for planning, particularly in health services, and is indicative of a region's socio-economic development. Beyond demographic aspects, sex ratio also reflects social conditions such as women's literacy rate, their status, decision-making roles, gender equality, and the impacts of women empowerment initiatives. Positive sex ratio, observed in developed societies with high literacy and empowerment programs, contrast with negative sex ratios seen in regions influenced by biological, demographic, socio-economic, and cultural factors. Such imbalances are evident in several districts of Karnataka, irrespective of region, where men face difficulties in finding brides due to the male favour child sex ratios. This research underscores the critical need for targeted policies and interventions to address declining child populations and sex ratios in Karnataka, aiming to promote gender equity and ensure a balanced demographic future and underscore the need for stringent policies against female foeticide and supportive measures for girl children.

## **References**

- Chandna R.C. (2016), "Geography of Population: Concept, Determinants and Pattern", Kalyani Publication.
- "Children in India 2018, A statistical approaches". Social Statistical division, Ministry of Statistics and Programme Implementation, Government of India.
- District level study on child marriage in India (2015), UNICEF.
- Guilmoto CZ and Rajan (2013), "Fertility at District Level in India: Lessons from the 2011 Census", Working Paper, University Paris Descartes, INED, IRD, Paris, June 2013. Available on <http://www.ceped.org/wp>
- Female age at Marriage An analysis of 1991 census data, Government of India.
- Female age at Marriage an Analysis of 1981 Census Data\_ Occasional Paper No. 7\_1988, 50781\_1981\_FEM. Government of India.
- Henry S. Shryock, Jacob S. Siegal and Associates (1976), "The Methods and Materials in Demography", Academic Press. INC London Sydney.
- "Karnataka state child protection policy" (2023), Department of Women and Child Development, Government of Karnataka.
- "Population projection India and state 2011-2036" (2020), National Commission On Population, Ministry Of Health & Family Welfare, Nirman Bhawan, New Delhi – 110011.
- Ranganatha (2024), "Geography of Karnataka", Mysore Book House.
- Saritha K. and Chandrashekar B. (2015), "Regional patterns of Population Ageing and Quality of Life Of Elderly in Karnataka", submitted to University of Mysore, Mysuru, for award of Doctoral degree in Geography.

- S.B. Ganiger, "Determinants of age at marriage in Karnataka during 1971-1981: a district level analysis", PMID: 12319425, Journal of Institute of Economic Research.
- Sex composition age distribution and marital status of population, <https://www.stat.go.jp/english/info/meetings/cambodia/pdf/chap3.pdf>.
- "Statistics on Children in India, Handbook" (2018), National Institute of Public Cooperation and Child Development, New Delhi.
- Tripti Bhushan (2021), "Of Female Foeticide and Its Causes in India", the Daily Guardian. Updated on: November 11, 2021, 7:00 am IST.
- "Understanding Child Migration in India" (2020), UNICEF.
- "World Fertility Report 2007", Department of Economic and Social Affairs.
- "World Population Prospects 2022", Department of Economic and Social Affairs.
- Chander Shekhar and Faujdar Ram, "Declining Juvenile Sex Ratio in India: Theoretical Investigations", *Nüfusbilim Dergisi\Turkish Journal of Population Studies*, 2003, 25, 97-109.
- W.T. Russell, statistical study of the sex ratio at birth, The London School of Hygiene and Tropical Medicine (manuscript received for publication 29. v. 1936).

--Dr. Saritha. K  
Associate Professor  
Department of Geography  
Government Frist Grade Collage  
K. R. Nagara Taluk, Mysuru District  
(Karnataka)

--Dr. S. Srikanta Prasad  
Associate Professor  
Department of Geography  
Government Frist Grade Collage  
Bannur, T. Narasipura Taluk  
Mysuru District (Karnataka)



## **ASSESSMENT OF SANITATION FACILITIES AND WASTE DISPOSAL PRACTICES IN SELECTED SLUM AREAS OF UPPER ASSAM, INDIA**

Preeti Barsha Borah and Lanusashi Longkumer

### **Abstract**

A slum represents an informal residential area, where a disadvantaged demographic with a low standard of living resides. These areas constitute an integral component of urban space. Upper Assam, located in the eastern Brahmaputra valley has been selected for the study. The rapid population growth has led to a range of associated issues, including pollution, lack of sanitation facilities, improper waste disposal, poor air quality, and the emergence of slum areas. This research aims to understand the proliferation of slums and their environmental conditions in five districts of Upper Assam, India. To assess the environmental aspects, this study examines sanitation facilities, waste output and its disposal methods practices in the slums. Findings reveal a shortage of latrines with inadequate facilities and practices improper waste disposal methods. This research aims to highlight on the environmental condition and their impact in slum areas and discusses some strategies for sustainable development of slum areas.

### **Introduction**

Slums characterised by unplanned settlement issues, have grown over time, leading to a daunting task of urban rehabilitation. Slum dwellers face a multitude of common issues, services such as improper garbage disposal and inadequate toilet facilities. Including the absence of basic amenities, poor health conditions, social vulnerability and insecurity, exacerbating poverty and often resulting in lower educational attainment, lost income due to illness, increased health care expanses, hence remain the most marginalized lot in the urban society. Slum conditions emerge from the combined effects of the ageing of buildings, lack of care and neglect, inadequate sanitation, inappropriate disposal of sewage, solid wastes and improper land development (Olotuah, 2012). Rapid population expansion has led to an increase in the number of slum settlements in urban areas. UN-HABITAT defines

a slum as a decrepit section of a city with poor housing, squalor and no tenure security. According to the UN-Strategic Habitat's Vision, by 2050, two-thirds of the world's population would live in cities, including 3 billion urban slum residents (UN Report, 2014). Slums are growing at a rate 5 to 10 times quicker than the rate at which the international community expects them to be upgraded. In India, the rapid growth of the urban population has accelerated the growth of the slum population. In Assam, the presence of slum communities on wetlands continues to endanger the existence of the city's water bodies (Takyi S. et al., 2020). The main challenges observed in the waste disposal by urban slum families include the lack of dustbins, the sporadic visits of municipal vans for domestic waste collection and a lack of awareness about the need for waste segregation (Nirgudi et al., 2014). According to UN-Habitat data, as of 2020, India accounted 49 percent the total urban population living in slums. India is lagging behind on 19 out of 33 Sustainable Development Goal (SDG) indicators, including health, poverty, sanitation and gender equality. The objective of this study is to examine the sanitation facilities, waste output and their disposal practices, to understand the state of environmental condition in slums of upper Assam and discussed some strategies for improvement.

### **Study Region**

The Upper Assam an administrative division of Assam, covering a geographical area of 19,025 km<sup>2</sup>, is drained by the Brahmaputra River and its tributaries. The region experiences an average rainfall 2045 mm and an average temperature of 23°C. This study focuses on the slum areas of four districts of Upper Assam: Golaghat, Jorhat, Dibrugarh, and Tinsukia. The area located between 26°75' North latitude to 95°22' East longitudes with an average elevation of 80 metres from mean sea level. The region is bounded by Arunachal Pradesh on the north eastern side and Nagaland in the south and eastern side of Upper Assam. According to the 2011 census, Dibrugarh and Tinsukia districts have the highest number of slum population, located in the eastern part of Assam.

### **Objectives**

This paper is to assess the sanitation facilities and waste disposal practices in Upper Assam, India.

### **Database and Methodology**

The initial phase of the investigation involves conducting a comprehensive literature review. Specific locations of interest are chosen randomly based on the

information obtained from district municipality offices. A sample size comprising 30% of the total number of slums and 30% of the total households from each selected slum was taken. Slum dwellers were interviewed individually and collectively by using a scheduled survey to gather information about their personal experiences and environmental challenges. Through this process, data on basic information of slums, household garbage output and its management were collected and analysed.

## **Results and Discussion**

According to the United Nations world population prospects data (2023), India is the most populous country in the world, comprising 17.76% of the global population. In India, Assam held the 15th position with a total population of 3.12 million, reported by the 2011 census. According to data published by the Registrar General and Census Commissioner of India, the slum population of Assam increased from 84,644 in 2001 to 197,266 in 2011. The report of the Town and Country Planning Organisation's (2011) stated that around 17.4% of India's population lives in slums. In Assam, around 2 lakh people inhabit slums across 31 towns (<http://www.censusindia.gov.in>). Several slum enclaves are rapidly expanding in Assam. Upper Assam accounts for approximately 16% of the total slum population within Assam. Dibrugarh has the largest slum population with 27,089 persons, constituting 13.73% of the total slum population in Assam. Assam's slum population percentages in Guwahati, Silchar, Dhubri, and Nagaon are 13.05%, 11.53%, 9.38%, and 9.18%, respectively as reported by district census handbook (2011). Most of the third world countries are facing problems associated with housing, including inadequate sanitation, lack of clean drinking water facilities, unplanned road networks and drainage systems, inadequate water supply, prevalent in the study areas.

## **Sanitation Facilities**

Slums, generally suffer from inadequate sanitation facilities. Unsanitary toilets pollute groundwater, with their impact influenced by soil characteristics and the proximity of water sources to the toilets. Due to slum overcrowding, there is not enough space between pit latrines and wells for microorganisms to migrate from latrines to water sources. Poor sanitary conditions in these overcrowded slums contribute to the pollution of the wells (Kimani-Murage, 2007) (Fig. 1). Inadequate waste disposal and drainage systems pose health hazards. Furthermore, haphazard construction in certain slum areas exacerbates these challenges, collectively impacting a city's overall environment (Zaman et al., 2018). The Golaghat Harijan colony, stands out, with a few residents having private pucca flush toilets connected

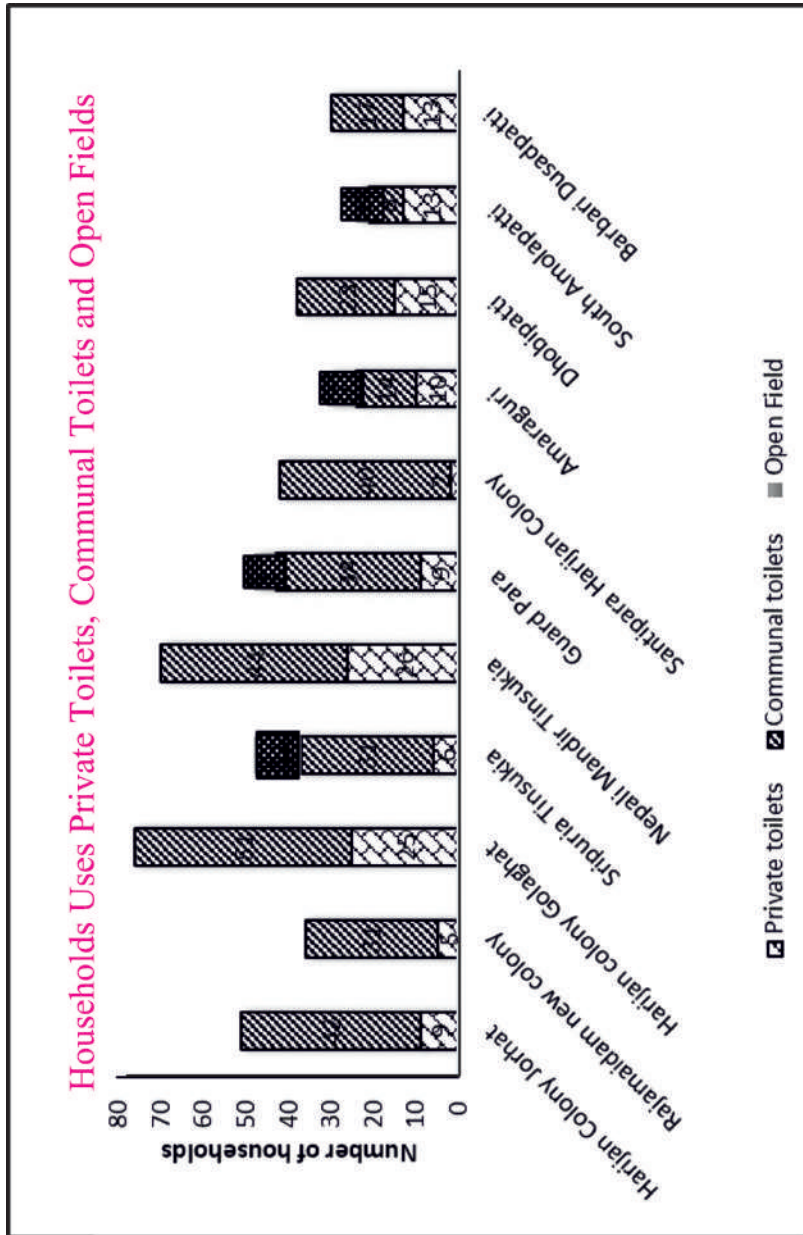


Fig. 1

with water supply taps. However, this slum also features a run-down community toilet that is used by residents who cannot afford to build their own. In Dibrugarh and Tinsukia, slums exhibit very poor sanitary services with toilets directly connected to rivers and drains. The communal kutchha pit toilets in unsanitary condition, especially in the Amaraguri and Guardpara slums. The residents of the Sripuria slum in Tinsukia only have three communal Kutchha pit toilets, all of which are in very poor condition. The toilets in Santipara slum are in disrepair and seem to have been turned into trash. In this slum, 15 families have to share one tube well and one communal toilet (Fig.1). Dwellers in Guardpara, Amaraguri and Sripuria also resort to using open fields for sanitation. Private toilets are scarce in all the slums, with a total of 27.47% (133) households having private toilets. Among these, 24.60% (31) are kutchha toilets and 75.39% (95) are pucca toilets. There are a total of 15.91% (77) common toilets in the study area, comprising 44% (34) kutchha and 55.84% (43) pucca toilets. Dwellers, especially those living near rivers and railway lines, use open fields due to the shortage of toilets. Sripuria, Guard Para and Amaraguri slums reported that open fields are sometimes used by the dwellers. Based on the field investigation data, it was determined that total 27.48% households use private kutchha and 69.21% households rely on communal toilets, predominantly in the Santipara, Rajamaidam new colony, Sripuria, Dhobi Patti, South Amolapatti, and Barbari Dusadpatti. However, slum dwellers occasionally resort to using open fields due to the shortage of available toilets and total 5.37% of total households reported on this statement predominantly from Sripuria, Guard Para and Amaraguri slum areas. The scarcity of toilets, coupled with their limited availability and the lack of regular cleaning, results in a multitude of problems. These issues extend from social and communal challenges on one side to the creation of unsanitary conditions, which serve as breeding ground of all infectious diseases such as dysentery, cholera, skin diseases etc. The insufficient number of latrines forced the inhabitants to use the open spaces for defecation. Young children defecate in the drain or any accessible open area, thereby contaminating the entire environment. The sanitary conditions of toilets in Santipara and Amaraguri slums are notably unhygienic.

### **Household Garbage Output**

Urban areas face significant challenges in waste disposal and management. These challenges are particularly pronounced in slums, where the distinction between biodegradable and non-biodegradable waste is often unclear (Photo-1).



Photo: 1- Toilets on Bank of The Brahmaputra River



Photo: 2- Communal Toilet in a Slum

According to the report published by Ministry of Statistics and Programme Implementation, Government of India (2013), at the all-India level, 27% of all slums had no garbage disposal arrangement. About 38% in non-notified slums and about 11% in notified slums do not have proper garbage disposal arrangements. The quantity of waste generated by households varies and is not measured by the residents. Based on their food habits and daily activities, households waste generation ranges from approximately 1 to 3 kg with a peak of 4 kg per day. The predominant waste output falls within the 1 to 2 kg/day, reported by a majority of respondents, comprising 184 (56%). No responses received on more than 5 kg garbage output (Table-2).

Table-2: Garbage Output (Kg/day)

Garbage output kg/day	Frequency	Percentage
Below 1	89	18%
01 to 2	184	38%
02 to 03	115	24%
03 to 04	63	13%
04 to 05	33	7%
Total	484	

Source: Authors

Environmental degradation arises from various factors. One prominent contributor is domestic waste, coupled with the accumulation of refuse by slum dwellers. Slums, characterised by absence of adequate trash disposal facilities, exhibit a lack of waste management practices. The prevalent methods of waste disposal primarily involve haphazard throwing and burning. Open dumping is frequent in the slums, with instances of household waste being deposited directly into the riversides by slum dwellers, as observed in Guardpara, Dhobi Patti and Amaraguri slums. Furthermore, in Santipara and Dhobi Patti slum areas in Dibrugarh town, households discard their waste directly into the open drains. Similarly, residents of the Rajamaidam new colony and Harijan Colony in Jorhat town habitually dispose of all types of waste into the Tocklai stream. The study findings reveal a minimal response to waste segregation, with only 17% of the population affirming adherence, while 83% of respondents indicated a lack of waste separation practices. Occasionally, slum residents' resort to reusing plastic bags and water bottles before disposing of them (Fig. 2).

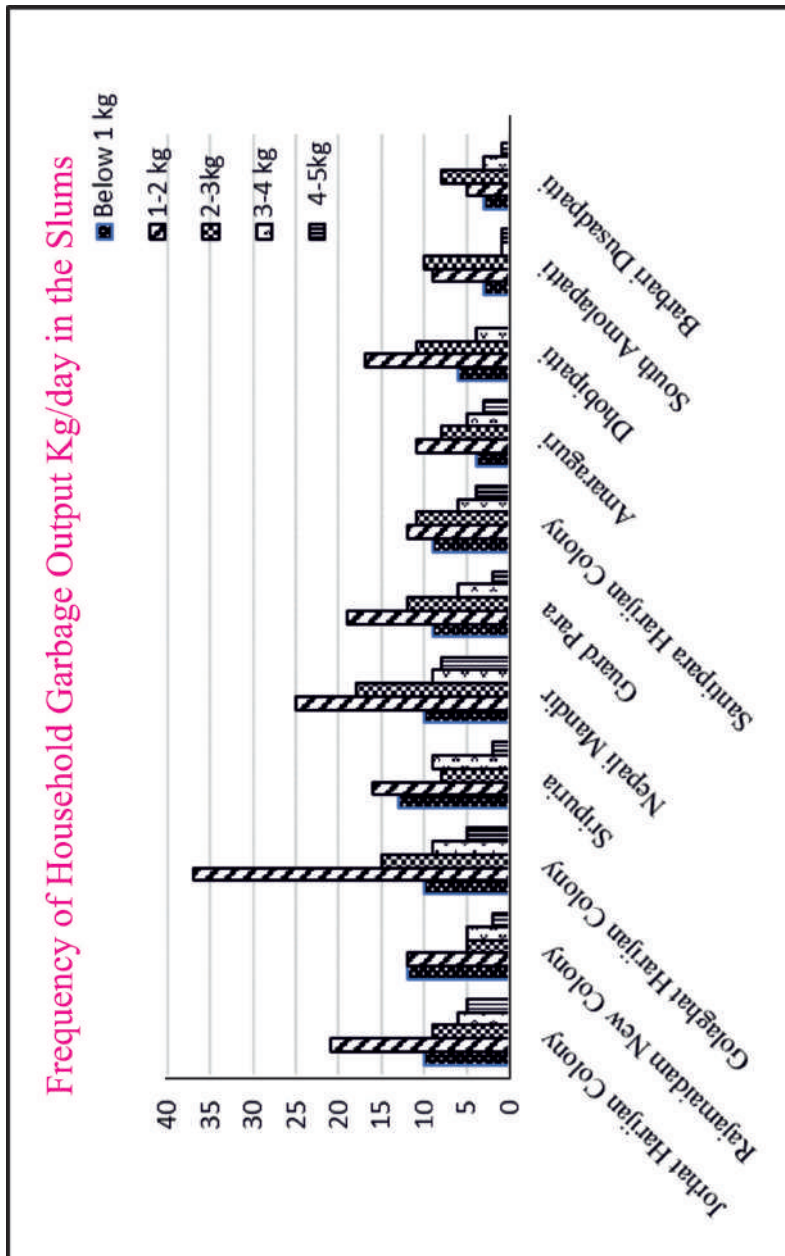


Fig. 2

A prevalence of improper toilet facilities is the major contributor to the occurrence of common diseases among the substantial population in these settlements. The Use of open fields for defecation and bathing not only reflects the shortage of space and sanitary facilities but also highlights concerns about privacy and social security, especially for women. The SDG-6, aims to provide adequate sanitation and hygiene for all and end open defecation by 2030. However, sanitation facilities in Sripuria, Amaraguri, Santipara slum areas are very poor and unrepaired condition. Additionally, improper domestic waste disposal practices continue to prevail due to a lack of awareness and knowledge among households. Many households' resort to disposing of their domestic waste in nearby drains, open areas, and riverbanks posing severe threats to both soil and water quality. In case of Guardpara and Amaraguri slums, inhabitants utilize empty spaces near the Brahmaputra River embankment for waste disposal. Given the widespread reliance on Brahmaputra River water for various daily activities, the contamination of this vital water source raises concerns about public health and ecological sustainability. Additionally, findings indicate that some households opt to dispose wastes anywhere in their residences, exacerbating the environmental challenges. Addressing these practices necessitates a comprehensive approach involving education, awareness campaigns, and improved waste management infrastructure to mitigate the detrimental impact of improper waste disposal on the environment and public health

### **Strategies for Improvement**

The slum improvement can be possible by studying the size of their problems by successfully implementing of available resources and capabilities (Rankey, 2018; Ragheb et al., 2021). Teferi and Newman (2017) suggested that slum policies could be shift from the Modernist high-rise slum clearance approach to a more organic, community-based renewal of slums themselves. In this approach, infrastructure for energy, water and waste can be brought in and discussions can focus on extended metabolism model or organic model of slum development. Unhygienic sanitation facilities lead to poor health conditions in slums. Constructing and maintaining community toilets and bathing facilities according to dwellers' demands are necessary to improve sanitation and hygiene. Due to the shortage of toilets, people sometimes resort to using open fields. Therefore, the first step is to assess how many people will utilize the communal toilets. In some slums, communal toilets are existed but lack water supply systems, posing another issue to be kept in mind during the construction of toilets by planners and slum dwellers. Proper sanitation facilities

will also contribute to preventing the privacy and social security of women in the slums. Unhygienic sanitary condition can be alleviated by providing awareness programs and educating slum dwellers about the importance of personal hygiene, proper waste disposal and sanitation practices. Shortage of space is a reason for improper waste management practices in slums. Slum residents do not practice separating degradable and non- degradable waste; instead, they dispose of and burn household waste. Therefore, it is essential to introduce a waste management system in slums that includes door-to-door collection, proper segregation and disposal methods. Engaging slum community members in waste processing units should be set up for recycling and converting organic waste into compost or biogas, offering employment opportunities and income generation. The establishment of local committees should be set up to ensure participatory decision-making in the development process. Livelihood and income generation can be accomplished by identifying vocational training opportunities aligned with local market demands and the skills of slum residents. Facilitating access to microfinance and credit schemes for self-help groups or individuals to start small businesses or income-generating activities is essential. Investing in training programs for local leaders and community members to build their capacity in managing various aspects of slum development, including waste management, sanitation, and infrastructure maintenance etc. are crucial.

## **Conclusion**

This paper highlighting the challenges slum areas pose and their impacts in eastern part of India, particularly in the Tinsukia and Dibrugarh towns, which have a high number of slums and slum dwellers in the Upper Assam region. The results of this study confirm previous research on sanitation, waste disposal facilities (Kimani-Murage, 2007; Nirgudi et al., 2014; Khan et al., 2023). The findings revealed that slums and its population are increasing along with many problems such as improper garbage disposal, shortage of latrines. In the slum areas, improvements have been observed in the Golaghat Harijan colony compared to the rest of the other slum areas. However, a limitation of the study is the lack of updated data on allocation of communal toilets. Standards of living of slum dwellers can be raised by providing better infrastructure, promoting environmental awareness, developing human resources and monitoring these urban settlements. There are many potentials within these slums to achieve sustainable development goals. It is vital for policymakers, researchers, government and non-government agencies

and slum communities to collaborate in order to implement targeted strategies. Adopting a holistic and integrated approach to environmental management is vital in our collective pursuit of creating healthier and more sustainable living conditions for both current and future generations.

## References

- Census of India, (2011). Assam, District Census Handbook, Dibrugarh, Series 19, Part XII-A.
- Ghosh, S. (2013). Regional Disparities of Slums, An Overview with Special Emphasis to Kolkata, *International Journal of Humanities and Social Science Invention*, ISSN: 2319-7722, Vol.2, I.3, Pp.48-54.
- Hossain S., Khan T. F., Huq S.M. Imamul. (2017). Effects of Slums on Ecosystem Components, *J. Asiat. Soc. Bangladesh, Sci.* 43(1): 71-81.
- Khan, S., Rathor, D., Singh, A., Kumari, R., Malaviya, P. (2023). Socio-economic and environmental vulnerability of urban slums: a case study of slums at Jammu (India), *Environmental Science and Pollution Research*. doi.org/10.1007/s11356-023-30630-5.
- Kimani-Murage, E.W., Ngindu, A.M. (2007). Quality of Water the Slum Dwellers Use: The Case of a Kenyan slum. *Journal of Urban Health*. Nov; 84(6):829-38. doi: 10.1007/s11524-007-9199-x. Epub, PMID: 17551841; PMCID: PMC2134844.
- Kondapi, A., Kumar, T., Sait, U., Bhalla, K., Ashok, S. S. (2019). A case-study of slums: An informal housing for people below poverty line (BPL) in India, *Journal of Physics: Conference Series*.
- Muindi, K., Kimani-Murage, E., Egondi, T., Rocklov, J., Ng, N. (2016). Household air pollution: Sources and exposure levels to fine particulate matter in Nairobi slums. *Toxics*, 4(3), 12.
- Nirgude, A. S., Naik, P., Prashad, V. G., Nagaraj, K. (2014). Solid Waste Disposal Practices in an Urban Slum Area of South India, *Indian Journal of Applied Research*, Volume: 4, Issue: 11,
- Olotuah, A.O. (2012). Slums, *International Encyclopedia of Housing and Home*, doi: 10.1016/B978-0-08-047163-1.00532-4.
- Government of India, Ministry of Statistics & Programme Implementation, (2013). Press Information Bureau.
- Government of India, Ministry of Home Affairs, Office of the Registrar General & Census Commissioner, India (2013). Primary Census Abstract for Slum, censusindia.gov.in/2011-Documents/ Slum-26-09-13.
- Rankey, K. (2018). A framework for creating positive change: solutions for slum important through local empowerment. *Michigan Sociol Rev* 32: 148–169. <https://www.jstor.org/stable/26528600>.
- Ragheb, El-Ashmawy (2021). Strategic actions of urban development to define the intervention policies of slums, *City Territ Archit* 8:10, doi.org/10.1186/s40410-021-00139-w.
- Government of India, Ministry of Housing and Urban Poverty Alleviation (2015). Slums in India-A Statistical Compendium, National Buildings Organization.
- Teferi, Z.A., Newman, P. (2017). Slum Regeneration and Sustainability: Applying the Extended Metabolism Model and the SDGs, *Sustainability*, 9, 2273 dx.doi.org/10.3390/su9122273.
- Takyi, S. A., Amponsah, O., Yeboah, A. S., Mantey, E. (2020). Locational analysis of slums and the effects of slum dweller's activities on the social, economic and ecological facets of the city: Insights from Kumasi in Ghana. *Geo Journal*, doi.org/10.1007/s10708-020-10196-2.

- United Nations (2013). The Millenium Development Goals Report. New York, NY: United Nations
- United Nations (2014). Slum population as percentage of urban, [mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=710](http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=710).
- Zaman, T., Goswami, H. D., Hassan, Y. (2018). The Impact of Growth and Development of Slums on the Health Status and Health Awareness of Slum Dwellers. *International Journal of Medical Research & Health Sciences*, 7(3): 55-65.

--Preeti Barsha Borah  
Research Scholar  
Department of Geography  
Nagaland University  
Lumami (Nagaland)

--Dr. Lanusashi Longkumer  
Professor  
Department of Geography  
Nagaland University  
Lumami (Nagaland)



## **ASSESSMENT OF FOOD WASTE AWARENESS OF STAKEHOLDERS IN AJMER, RAJASTHAN**

Atul Jain, Dr. Rashmi Sharma and Dr. Ashutosh Kumar Pandey

### **Abstract**

Food waste prevention is good for the environment, the economy, and for society as a whole. While a significant portion of the population struggles to get access to basic food, a considerable amount of high-quality food is wasted every day. Considerable work has been done recently to better understand food waste in situations where people eat outside the home. Nonetheless, the majority of research has been carried out mainly in developed nations. Even though the wedding industry is one of the biggest producers of food consumed outside the home, especially in developing nations like India, little is known about the quantity of food that is wasted. The purpose of this study was to achieve two objectives. First, to evaluate the trend and reason behind food waste at wedding receptions. The second goal is to find out what different stakeholders think about food waste in the wedding sector. Convenience and snowballing non-random sampling techniques were used to recruit participants online via Google Forms and offline via schedules of 195 stakeholders involved in wedding food waste, including guests, hosts, caterers, event organizers, freelance artists, photographers, and managers of various wedding venues. According to the study's findings, about three-quarters (70%) of stakeholders are aware that food waste occurs at wedding events and roughly half (48.1%) of stakeholders agree that food waste at weddings is a significant environmental issue. Nonetheless, when asked how much of the meal they believed they had left uneaten at a recent wedding, over 50% of respondents said they had left less than 10% of it. The desire to eat everything from the wide variety of dishes served at the buffet led to the majority of unfinished dishes being returned. According to half of the respondents, the majority of food waste is disposed of in the trash after a wedding. More than three-quarters (78.3%) of respondents believed that the host, caterers and wedding planner were all to blame for the food waste. Sufficient educational initiatives are required to increase public awareness of food waste during wedding festivities. Furthermore, food waste can be minimized by limiting the quantity of dishes and guests.

## **Introduction**

Food is crucial for survival, health, social interactions, and economic well-being. It is also essential for maintaining connections to heritage and celebrating special occasions. However, food insecurity and hunger are pervasive issues, particularly in developing nations. Malnutrition and chronic hunger affect millions worldwide, contributing to climate change, environmental degradation, and depleting resources. In 2023, India's Global Hunger Index is 28.7, indicating alarming levels of food waste. Approximately 14% of the food produced for human consumption is lost, and 17% is wasted, with 11% occurring in households, 5% in the food service industry, and 2% in retail. One third of the food produced for humans in the world is either wasted or lost. The Sustainable Development Goal's Target 12.3 aims to reduce global food waste per person at the retail and consumer levels by half by 2030. However, the world is off track in its efforts to halve per capita food waste and losses. In 2019, approximately 931 million tonnes of food waste were produced, with 61% coming from households, 26% from food service, and 13% from retail. On average, each person wastes 120 kg of food per year. Reducing food waste at retail, food service, and household levels can have positive effects on environment, food security and climate change. The current study focuses on food waste at the consumption level, particularly in the food service industry, especially during wedding events catering. India produces 286.20 million tonnes of food waste, with 38% coming from households, 34% from manufacturing, 17% from food service, and 11% from retail. Out of 125 countries, India ranks 111th in the Global Hunger Index 2023, down from 107th in the 2022 index. The study emphasizes the importance of reducing food waste at retail, food service, and household levels for environmental, food security, and climate change benefits. It specifically focuses on food waste in the food service industry, particularly during wedding events catering, where high-calorie food and litter are left after the event.

## **Study Region**

With a total land area of roughly 3.42 lakh sq. km., or 10.41 percent of the nation's total land area, Rajasthan, also known as "The Land of the Kings," is the largest state in the nation. It is located in the northwest region of the nation. Rajasthan State holds a significant position on the global tourism map and is among the most visited tourist destinations in India. Both domestic and foreign tourists can enjoy a variety of tourist attractions there. The Luxury Train (Palace-on-Wheels), Forts, Palaces and Havelies, Fairs and Festivals, Handicrafts, Heritage Hotels, Religious Tourism and Temples, Classical Music and Folk Dance, Wedding Tourism,

and so on are some of Rajasthan's Unique Selling Propositions (USPs) that draw tourists to the state and produce income and employment for the state. Ajmer is well known for its colorful culture, extensive history, and breathtaking architecture. Nestled amidst the hilly terrain of the Aravalli Range and its outliers, Ajmer is drained by Luni River and tributaries of the Banas River. The Dargah Sharif, is especially well-known for drawing pilgrims from all over the world during the yearly Urs festival. Historical and religious sites like the Akbari Fort and Museum and Ana Sagar Lake are located in Ajmer. The city is renowned for its stunning architectural designs, which include the Adhai Din Ka Jhopra mosque and Taragarh Fort. Additionally, Ajmer has a long history of producing textiles, handicrafts and rose farming, with colorful bazaars selling a wide range of goods. Another noteworthy component of its cultural heritage is the food of the area. Resorts in and around Pushkar is also a large tourist attraction not only for Indian but for foreign tourists as well. Exquisite hotel chains make Ajmer perfect destination wedding attraction. **Fig. 1** showing the study area map along with marked samples location from where data for the schedules were collected during research most of the hosts, caterers, event organizers, photographers, and managers are associated with these wedding venues. High concentration of sample location around Ajmer city indicates large number of wedding venues located in this region owing to pushkar and other tourist attractions.

### **Objectives**

- (1) To assess the pattern and cause of food wasted in wedding events in Ajmer District.
- (2) To examine the behaviours, attitudes, and awareness of those who may be connected to food waste in wedding events in Ajmer District.
- (3) Suggest measures to minimise food waste in wedding industry.

### **Database and Methodology**

This exploratory cross-sectional study is done by collecting primary data using questionnaire and schedules. The survey conducted includes various stakeholder related to food consumption or wastage of food in wedding events i.e. Guests, Hosts, Caters, Event organisers, Freelancer Artists, Photographer and Managers of different wedding venues. Out of 195 participants, 143 participates submitted forms electronically into Google Drive server and for 52 participants offline interview-based schedules were filled (Fig. 1). Individuals who reported having attended at least one wedding within the past year were included in the study. Perhaps the most

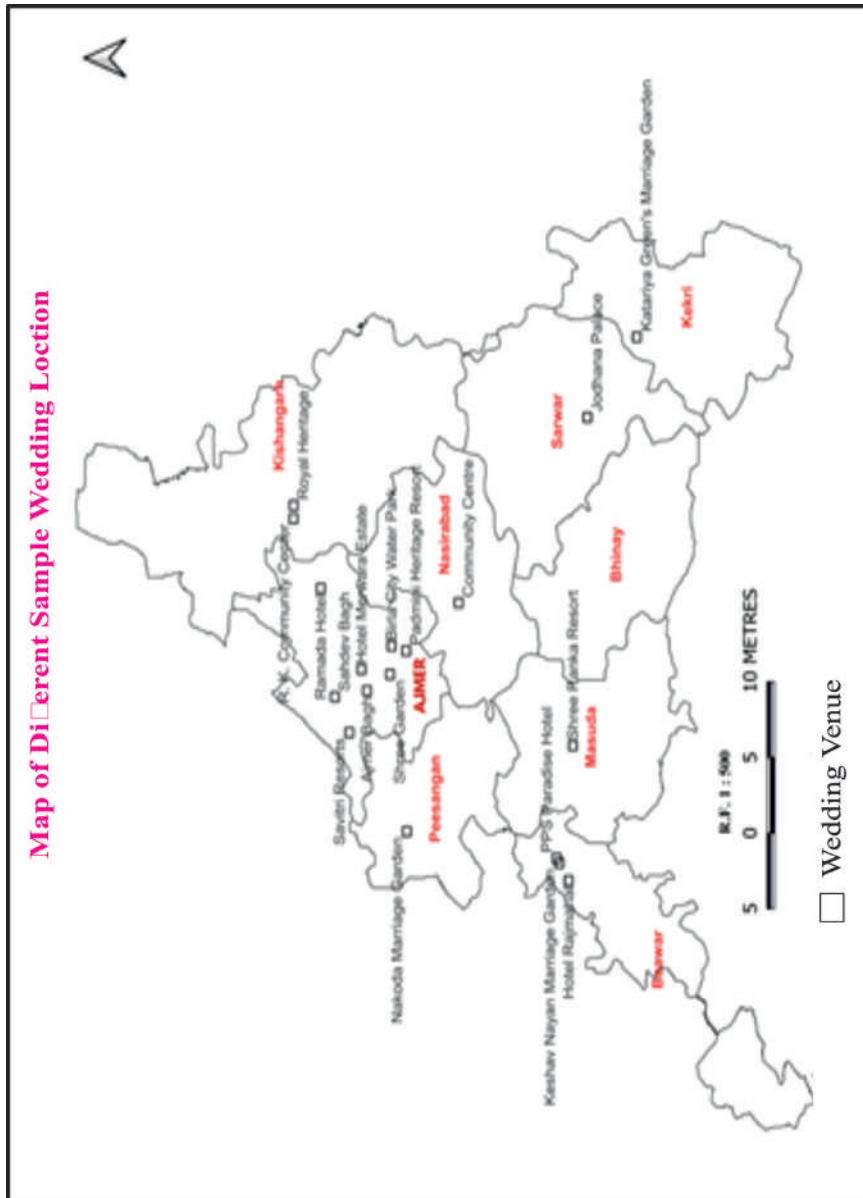


Fig. 1

important question in determining whether or not to participate in the study was “How many wedding events have you attended over the last 12 months.” Nearly 40% of the sample had attended more than 5 weddings, while 14% had attended 2 weddings in the last 12 months. In 2022-2023, initial data set was gathered through online surveys; subjects were selected using a convenience sampling technique, which involved sharing the link to the survey along with a description in WhatsApp groups and individuals chats which have attended weddings in Ajmer district in last one year. Subsequently, the second round of data originated from peers who were referred to the study by the initial respondents this method is called “snowballing.” The second set of data is collected by the author using schedules for the stakeholders like Caters, Event organizers, Hotel managers etc. so that each and every stakeholder can have decent proportion of participation in the study. The data is then tabulation and dataset in spreadsheets was cleaned up and exported to SPSS for analysis.

## **Results and Discussion**

### **Participant/Respondents characteristics**

There were more men (60%) than women (40%), and most of them belong to Rajasthan. The age of respondents ranges from 19-60 years with majority (16%) of participants were 32 years old, and the next largest age was 27 years, while very few were aged over 50 years. Approximately 69% of the participants belong to guest category while Hosts, Caters, Event organisers, Freelancer Artists, Photographer and Managers contributed approximately 4.1%, 6.2%, 6.7%, 6.7%, 3.6% and 3.7% respectively. All the respondents selected have attended at least one wedding over the last 12 months, in fact half of them attended at least 5 weddings and one fourth (25.6%) have attended 3 to 4 wedding in the past year.

### **Wedding Characteristics**

Most of the wedding attended by the participants is traditional (60.5%) and Destination (26.2%) in nature. Very few of them have attended an Eco-friendly wedding, showing that there is a lack of awareness or trend about the eco-friendly weddings and eco-consciousness in the society. Even temple wedding is attended by only 2 respondents. While most common venue of wedding was Hotel or Resorts (46.4%) and Marriage gardens (26.3%). Some wedding also took place in farmhouses, private properties and indoor banquet halls of Ajmer city (33.5%), Pushkar (23.7%) and Kishangarh (9.8%). Most of the Wedding host choose big hotels and resorts for their wedding ceremonies in Pushkar as it is emerging as

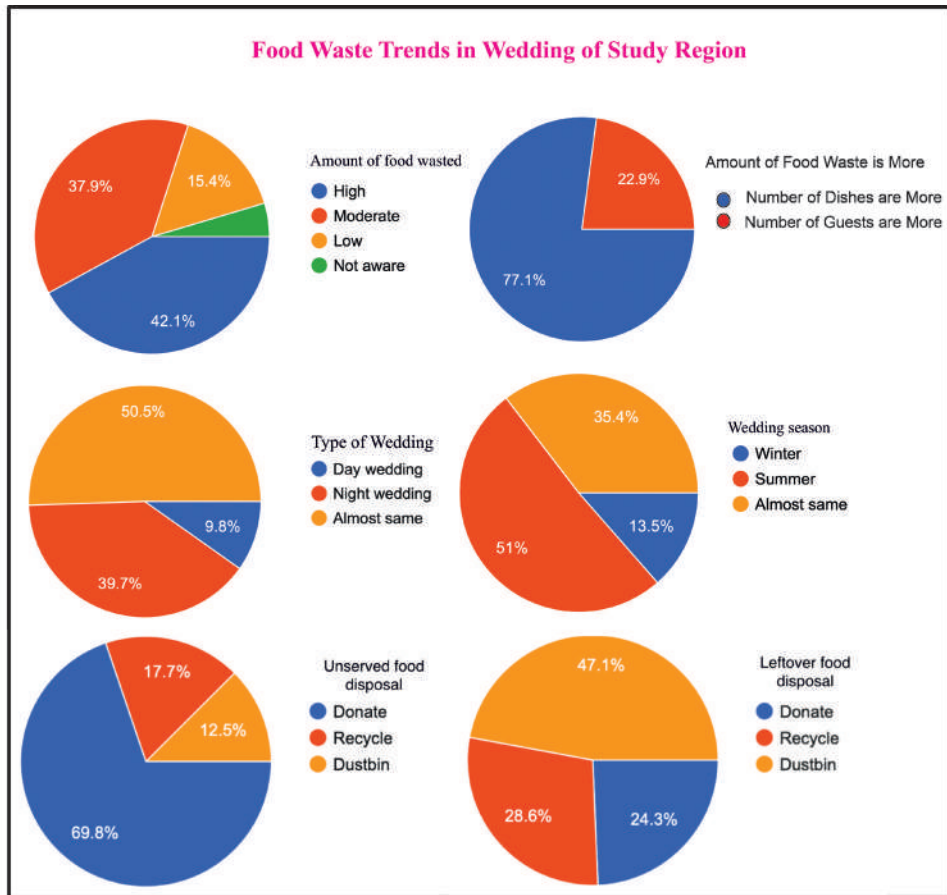


Fig. 2

it is a destination wedding hub in Rajasthan. The average wedding cost between 30 lakhs-50 lakhs in the area surveyed. As huge amount of money is being spent in organizing these lavish weddings which not only have the economic effect but it also affects the environment. As stated by a report one-fifth of the wealth the average Indian has accumulated in his lifetime is spent on child marriage. (Digital Job Advertising for India 2020). There was no wedding below 50 guests and in more than half (53.6%) of the weddings the number of guests ranged from 250-750 in number. While 21.6 % wedding have 750-1000 guests and approximately 13% of the wedding have more than 1000 guest attendees. Are huge surge can be seen on the number of guests attending the wedding in the post-covid scenario as there is no guest control rules operating in the state.

### **Pattern or Trend of Food Waste**

Of the 195 respondents, 80% felt that there was high-to-moderate food waste at the wedding, and 15% said that it was low. However, a small percentage (5%) do not know that food is wasted. Compared to food waste that occurs when there are more guests, more than three-fourths (77%) of the respondents believed that food waste occurs when there are more dishes served. When asked which function of the wedding generates the most food waste, the majority of respondents (68.4%) said that the reception because of the large selection of food items and buffet arrangement. However, 14% of those surveyed think that it happens during a pool party. According to half of the stakeholders, food waste levels at weddings during the day and at night are essentially the same. However, 39.7% of respondents think that there is more during a night wedding, and 9.8% think that there is more during a day wedding. In contrast to winter weddings, which are thought to produce roughly the same amount of food waste by 35.4% of respondents, 51% of respondents believe that summer weddings produce more food waste. A sizeable portion of respondents (48.7%) claimed that food waste mostly happens when leftovers remain on plates. Just a small percentage of respondents stated that food that is not served is wasted more than food that is left over, with 36.3% saying that the two are nearly equal (Fig. 2). Regarding food waste, 57.6% of respondents claimed that there is more in a buffet system when compared to traditional style serving on plates, while 24.6% believed that it is nearly the same in both situations. The majority of respondents (54.9%) stated that rice is the food item that is wasted the most, followed by veggies, chapatis, desserts, salads, snacks, and juices. According to the respondents' priorities (by the selection of 3 factors), the following are the main causes of food waste at wedding events.

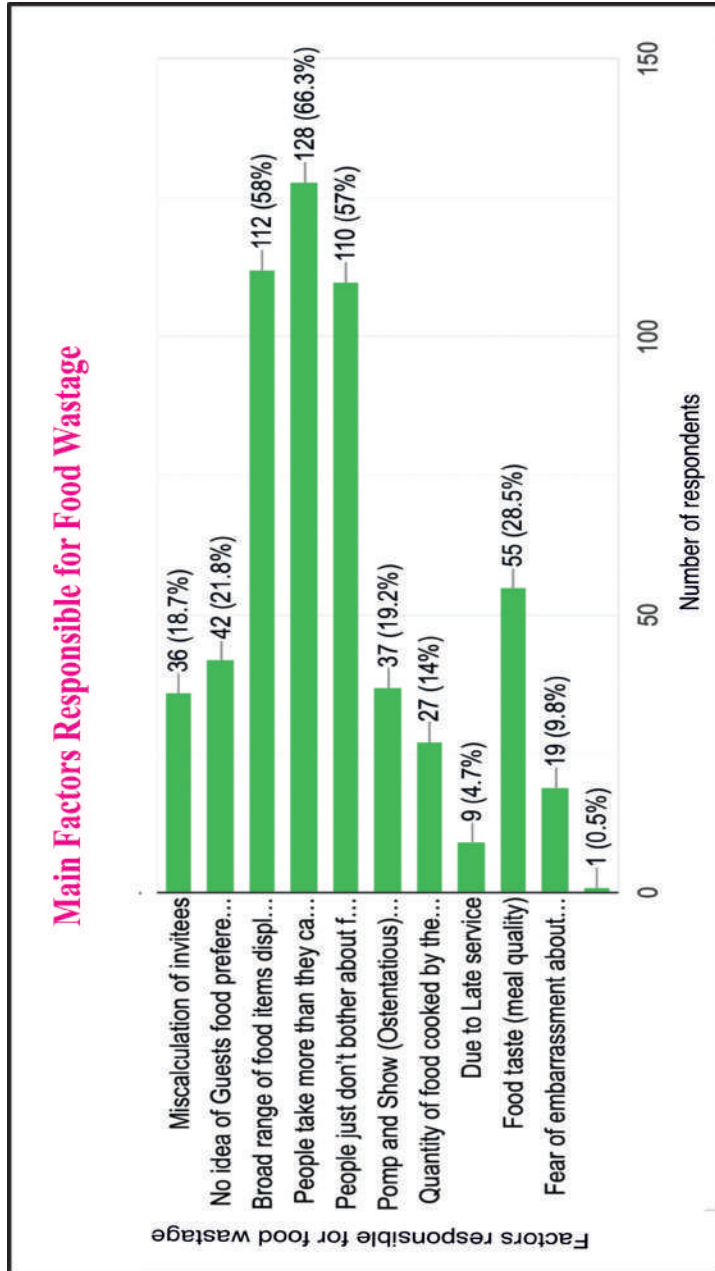


Fig. 3

- (1) People take in more than they can consume (66.3%)
- (2) Variety of foods offered at the buffet (58%)
- (3) People simply don't care that food is wasted; they are indifferent to it (57%)
- (4) Meal quality or food taste (28.5%)
- (5) Guest food preference unknown (21.8%).
- (6) Host's pompous and ostentatious behavior (19.2%)
- (7) Inaccurate invitee calculations (18.7)
- (8) Embarrassment fear related to emptying the plate (9.8%)
- (9) Owing to delayed service (4.7%).

The majority of respondents (46%) claimed that the extravagant food menu at weddings was primarily motivated by status symbols. Other significant contributing factors include social and relative pressure, which is attributed to 12.7% of respondents, competition to perform better (19% of respondents), and the prosperity of the economy in society (10.1% of respondents) (Fig. 3).

### **Fate of Food**

When asked what happens to leftover food after a wedding, a lot of respondents said that it is either thrown in the trash or dustbin (48.2%), eaten by animals (42.9%) or donated to non-governmental organizations (40.8%). A small percentage of respondents also think that it is sent to the compost pit (9.9%), recycled and reused (16.2%), and donated to an animal-care Centre (23%). Approximately 69.8% of respondents think that some of the Unserved foods should be donated. 12.5% of them think that the unserved food should be thrown in the trash, while 17.7% think that it should be recycled. Due to its lack of use, a large percentage of respondents (47.1%) think that the leftover food on the plate should be thrown in the trash. Only a small percentage of respondents (28.6%) think that it should be recycled, and 24.3% think that it should be donated. Many of the respondents think it is crucial to reduce food waste, and among the steps they prioritize in order to do so are the following.

- (1) Through campaigns for public awareness and education (35.3%)
- (2) By capping the quantity of dishes (26.3%)
- (3) By introducing a new law or act (13.7%)
- (4) By restricting the number of visitors (13.2%)
- (5) By the guest taking the extra food home (9.5%)

When asked which stakeholder was most responsible for effectively minimizing food waste, 46% of respondents said that the person in charge of organizing an event i.e. host could be that person, followed by caterers and wedding planners (32.3%).

### **Awareness**

The majority of respondents (70.8%) are aware that food waste happens at wedding events, while a smaller percentage (14.4%) claimed to be unaware of the fact and 14.9% to are unsure. Whereas when asked how much food they have left uneaten on their plate, 62.6% of the respondents said they have left less than 10%, and 22.1% said they have left between 10 and 30%, despite the fact that most people are aware of the food waste in the wedding industry. Merely 4.6% of the participants acknowledged that they had disposed of their plates in the trash after leaving more than 60% of food on them. A sustainable society urgently needs to control food waste and ostentatious behaviour, according to nearly all of the participants (95.2%). As a large amount of the food is wasted in wedding which tends to pose environmental threat in the same view, 48.1% of the respondents strongly agree about the fact that food waste causes environmental degradation while 37.6% of them believe agree on it. And few of them a neutral about this view. A significant portion of participants think that the food waste from weddings should be donated to non-profit organisations (64.9%), used as animal feed (55.1%), recycled and reused (16%), sent to a compost pit (10.1%), or used for biogas and composting (8%). Nine percent of them even stated that they would dispose of it in a trash.

### **Conclusion**

The Ajmer district is home to numerous destination weddings, with a significant portion of the expenses spent on food and drink. The variety of food served during these events contributes to food waste, with the majority of waste occurring during the reception. The main causes of food waste include the variety of dishes served and guests taking more than they can consume. The majority of wasted food ends up in landfills or is consumed by animals. To reduce food waste, the main players in the wedding industry are the host, catering, and event organization. The United States has implemented laws to address food waste, such as the Good Samaritan Food Donation Act and the USDA's "FoodKeeper" initiative. The state government should impose restrictions on guests and dishes to reduce food waste, and education

campaigns should be launched to raise public awareness of the negative effects of food waste and hunger. In the future, the green wedding industry may see an increase in the promotion of eco-friendly and sustainable practices.

## References

- 2023 Global Hunger Index: The power of youth in shaping food systems - World. (2023, October 12). ReliefWeb. <https://reliefweb.int/report/world/2023-global-hunger-index-power-youth-shaping-food-systems>
- Chaudhary, P., Garg, S. C., George, T., Shabin, M., Saha, S. K., Subodh, S., & Sinha, B. (2021). Underreporting and open burning – the two largest challenges for sustainable waste management in India. *Resources, Conservation and Recycling*, 175, 105865. <https://doi.org/10.1016/j.resconrec.2021.105865>
- Digital Classifieds In India (2020). KPMG, 21 Sept. 2016, [home.kpmg/in/en/home/insights/2016/09/digital-classifieds-india.html](http://home.kpmg/in/en/home/insights/2016/09/digital-classifieds-india.html)
- Down to earth. (2018). Now there's a way to offset food wasted at weddings. <https://www.downtoearth.org.in/news/food/now-there-s-a-way-to-offset-food-wasted-at-weddings-62466>
- Gc, (2019). The State of Food and Agriculture 2019. In FAO. <https://doi.org/10.4060/ca6030en>
- Gikuri, A. (2021). Wedding and Wasting: Exploring Food Plate Waste in Tanzania. *Journal of Social Sciences, Business and Technology (JSSBT)*, 2(1). <https://journals.cuk.ac.ke/index.php/JSSBT/article/view/52>
- Index, G. H. (2023, November 13). Global Hunger Index Scores by 2023 GHI rank. Global Hunger Index (GHI) - Peer-reviewed Annual Publication Designed to Comprehensively Measure and Track Hunger at the Global, Regional, and Country Levels. <https://www.globalhungerindex.org/ranking.html>
- Kim, B., & Neff, R. (2009). Measurement and communication of greenhouse gas emissions from U.S. food consumption via carbon calculators. *Ecological Economics*, 69(1), 186– 196. <https://doi.org/10.1016/j.ecolecon.2009.08.017>
- Misra S., Chadah S. & Pathania M. (2011). Report on Assessment of Wastage of Food and Ostentatious Behaviour during Social Gatherings (Marriages/ Parties/ Meetings, etc) in National Capital Region Delhi. Centre for Consumer Studies, Indian Institute of Public Administration.
- Posts, V. M. (2022, April 21). Green Weddings: The Zero-Waste Trend that Couples Need to Hop on. Lakes of India. <https://lakesofindia.com/2022/04/18/green-weddings-the-zero-waste-trend-that-couples-need-to-hop-on/>
- The State of Food Security and Nutrition in the World 2023. (2023). In FAO; IFAD; UNICEF; WFP; WHO; eBooks. <https://doi.org/10.4060/cc3017en>
- Sharma, N., & Vrat, P. (2018). Impact of various factors on stock-induced food waste in Indian weddings. *Journal of Advances in Management Research*. <https://doi.org/10.1108/jamr-09-2017-0087>
- Singh, A., Vohra, C., Mukherjee, A., Bodas, S., Singh, A., Singh, A., Singh, A., Singh, A., Freese, T., & Vohra, C. (2021, November 11). The rich waste food in ostentatious displays as the poor starve – The Weekly Observer. *The Observer*. <http://theweeklyobserver.in/2021/11/11/the-rich-waste-food-in-ostentatious-displays-as-the-poor-starve/>
- UNEP Food Waste Index Report 2021. (2021). UNEP - UN Environment Programme. <https://www.unep.org/resources/report/unep-food-waste-index-report-2021>

United Nations Statistics Division. (2023). SDG indicators. <https://unstats.un.org/sdgs/report/2023/>

Vyas, H. (2012, October 11). Wedding food worth Rs 339 crore goes waste. The Times of India. [https://timesofindia.indiatimes.com/city/bengaluru/wedding-food-worth-rs-339-crore-goes-waste/articleshow/16774949.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](https://timesofindia.indiatimes.com/city/bengaluru/wedding-food-worth-rs-339-crore-goes-waste/articleshow/16774949.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)

--Atul Jain  
15/176, Tikam Ganj  
Station Road, Ajmer  
(Rajasthan)

--Dr. Rashmi Sharma  
School of Earth Science  
Banasthali Vidhyapith, Banasthali, Niwai  
(Rajasthan)

--Dr. Ashutosh Kumar Pandey  
School of Earth Science  
Banasthali Vidhyapith, Banasthali, Niwai  
(Rajasthan)



## **ASSESSMENT OF AGRICULTURE DEVELOPMENT IN UTTAR PRADESH**

Ahmad Mujtaba Siddiqui, Tariq Mahmood Usmani and Afia Aslam

### **Abstract**

Agricultural development encompasses the progress and comprehensive agricultural transformations that lead to vertical expansion. When evaluating the progress of agriculture, it is essential to consider not only the level of productivity but also the use of inputs such as fertilizers, improved seed types, and irrigation. The Uttar Pradesh economy heavily relies on agriculture, the population's primary occupation. It employs over 66% of the workforce and contributes around 33% to the state's income. The majority of the population relies on agriculture as their primary occupation. The study relies on secondary data. The data of chosen variables has been extracted from multiple government reports from Krishi Bhawan, Lucknow. This study aims to evaluate the degree of agricultural progress throughout the districts of Uttar Pradesh. The data was analysed using several statistical approaches, such as Z-score and Principal Component Analysis (PCA). The data was determined using the tools MS Excel and IBM SPSS v20. Due to a scarcity of available data, the research includes just a limited number of crucial components, such as agricultural implements and cultivation instruments. Rural growth is primarily influenced by factors such as rainfall, irrigation facilities, the adoption of new technology, and the availability of agricultural infrastructure, which is well-recognized. Nevertheless, irrigation is the dominant and indispensable aspect of farming activities. Therefore, two irrigation variables were chosen. Cropping intensity has traditionally been evaluated by calculating the proportion of net sown area to the overall cropped area. In addition, the average land area distribution analysis has considered the variable net planted area per cultivator. The application of fertilizers has been examined by altering the quantity applied per hectare of land.

### **Introduction**

Agriculture encompasses all human activities that cultivate the earth to produce food, fodder, fuel, and fibre. However, agriculture is the deliberate action taken by humans to modify their surroundings to fulfil their needs better (Gopalakrishnan, 1992).

Agriculture has consistently held a prominent position in our country's economy. In 2013, agriculture and related sectors contributed 13.7% of the gross domestic product (GDP). Additionally, around 60% of the Indian population relies on this industry for their living. Evidence indicates that agriculture significantly contributes to India's social and economic advancement. The country's agricultural exports, valued at \$39 million, rank it the seventh largest agricultural exporter globally. Despite the financial contribution of agriculture and related sectors to India's GDP, there has been a consistent decline, suggesting gaps in reaching the intended output from the agricultural industry (Panwar, Rajdev, 2016). The agricultural growth rate for 2014-2015 is around 0.2%, whereas the economic growth rate is 7.3%. Nearly 68 percent of the working population is responsible for the production of agricultural output. In contrast, in 2009, just 2 percent of the population in the USA was involved in the agricultural industry. Similarly, in other industrialized nations such as Australia, barely 3 percent of the population works in agriculture. During the past several decades, there has been a slight decrease in the percentage of the working population involved in agriculture. This indicates that despite the industry's growth in the last century, more is needed to support most people who rely on agriculture. There is still more work to be done to properly develop the agricultural sector and eliminate its inequalities (Jain, G.L, 2010). A significant distortion marks the agricultural growth in India due to the unequal distribution of irrigation facilities and infrastructure across areas. Furthermore, the adoption of new high-yielding variety (HYV) seeds, fertilizers, and technologies has been uneven. Furthermore, the unequal distribution of land ownership has resulted in an inequitable sharing of development benefits among different groups of farmers (Bhalla & Tyagi, 1989). A combination of physical factors such as soil fertility, rainfall, weather, and existing technology and input levels primarily influences the regional distribution and rate of increase in agricultural production. Significant variations in soil fertility and moisture availability exist during the monsoon and irrigation periods. For a considerable time, the Indian subcontinent has exhibited substantial regional disparities in yield levels and increased agricultural output.

### **Study Region**

Uttar Pradesh is the most populous state in India. The state accounts for around 16.16% of India's population and nearly 2.9% of the global population. The extent of this region is 243,290 square kilometers, accounting for 6.88% of India's total geographical area (Guha & Chandra, 2021). Uttar Pradesh is located in the northern part of the nation, between latitudes 23°52'12" to 30°24'30" N and

longitudes 77°05'38" to 84°38'30" E (CGWB, 2016). Situated in the fertile Ganga Plain, this area is crucial in bolstering the nation's agricultural output. The fertile plain of the Ganga River has a much higher population density of 829 inhabitants per square kilometer, more than twice the national average of 382 individuals. The state is located in the north-central area of the country and is embellished by the meandering rivers of the Ganga and the Yamuna. Uttar Pradesh is a landlocked state that shares borders with Uttarakhand and Nepal to the north, Bihar to the east, Jharkhand and Chhattisgarh to the southeast, Madhya Pradesh to the south, and Rajasthan and Haryana, including the national capital territory of Delhi, to the west. Uttar Pradesh was initially formed in the United Provinces on April 1, 1937. It was then renamed Uttar Pradesh on January 26, 1950, to align with India's transition to a republic following the implementation of the States Reorganisation Act. Later, the state was officially acknowledged as Uttar Pradesh, indicating its position in the northern part of the country (Lata, 2019). In 1991, the state consisted of a total of 63 districts. On November 9, 2000, nine districts were transferred from the previous state to the newly formed state of Uttarakhand. Uttarakhand has thirteen districts in the Himalayan region and the district of Hardwar (Lata, 2019). Uttar Pradesh is partitioned into 75 districts and 350 tahsils—Lucknow functions as the state's administrative capital (List of Districts of Uttar Pradesh, n.d.).

### **Objective**

The present paper is to assess the level of agriculture development among the districts of Uttar Pradesh.

### **Database and Methodology**

The study is based on secondary data. The data of selected variables has been taken from the various government reports and Krishi Bhawan, Lucknow. Several statistical methods were used to look at the data, including Z-score, and Principal Component Analysis (PCA) MS Excel and IBM SPSS v20 tools were used to determine the data. Arc GIS v 10.3 made charts and maps that logically show the calculated data.

### **Z-score-**

**The values are standardized using the given formula**

$$Z\text{-score}=(X- \bar{X})/\delta$$

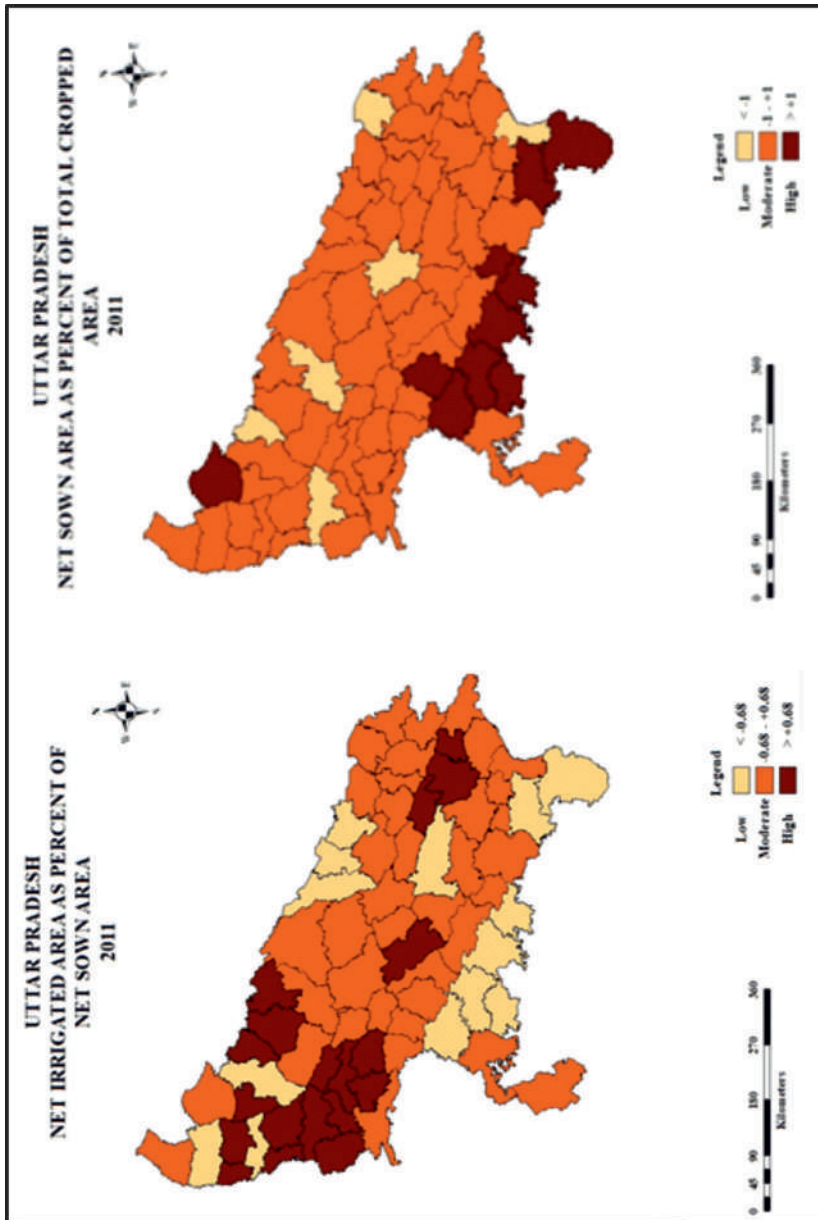


Fig. 1

Whereas,

$\bar{X}$  = mean value of the given indicator

X = individual value

$\delta$  = Standard deviation

The Z-score value of each variable will be used to determine the composite score for assessing the level of socio-economic development at the district level.

**Selecting Agricultural Development Indicators in Uttar Pradesh:** Pertinent comparative data from a trustworthy source determine the selection of variables. The research contains only some essential factors, such as agricultural implements and instruments for cultivation, owing to a lack of available data. Due to the unavailability of data on HVY seeds, they are not included in measuring agricultural development, although they are an essential factor. It is widely known that rainfall, irrigation facilities, the adoption of new technologies, and the availability of agricultural infrastructure primarily influence rural development. However, irrigation is the most crucial and significant factor in farming operations. Hence two variables related to irrigation has been selected. The assessment of cropping intensity has been based on the ratio of net sown area to total cropped area. Additionally, the average distribution of land area has been analysed by considering them variable net sown area per cultivator. The application of fertilizers has been investigated by varying the amount used per hectare of land.

Table-1: Total Selected Variables of Agriculture Variable

Sectors	Symbol	Variables
Agriculture and Allied Sectors Development	X1	Net sown area as percent of total cropped area
	X2	Per cultivator net sown area
	X3	Net irrigated area as percent of net sown area
	X4	Length of canal per 1000ha of net sown area
	X5	Consumption of fertilizers per ha. of total cropped area

## Results and Discussion

### Evaluation of Agricultural Development Indicators

#### Net Sown Area as Percent of Total Cropped Area (Cropping Intensity)

Cropping intensity refers to the percentage ratio of the total cropped area to the net sown area (Fig. 1). It entails the deliberation of cultivating many crops inside

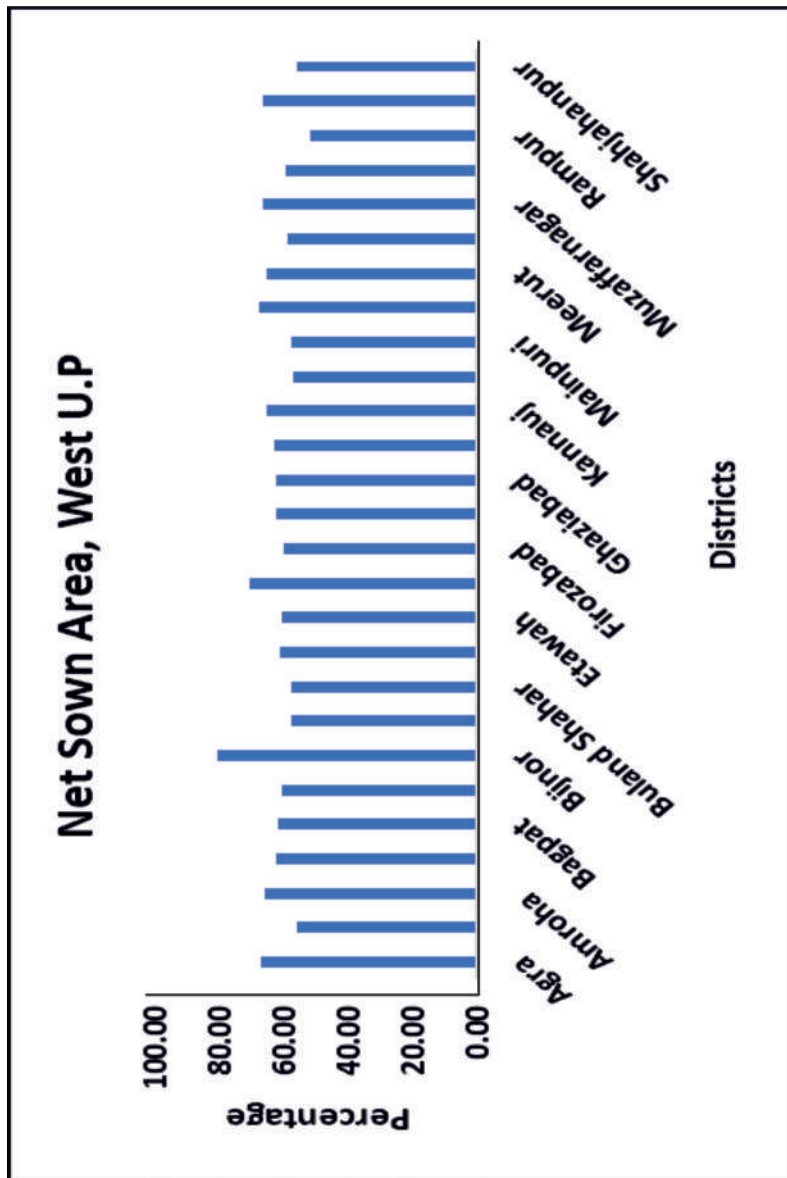


Fig. 2

a single unit of land throughout the year. **Figure** shows the spatial distribution of cropping intensity among the districts of Uttar Pradesh in the year of 2011. It shows the categorization of cropping intensity in three categories of high, medium and low on the basis of Z-score. There are ten districts which falls in high category among which five districts are located in Bundelkhand, four districts belong to eastern U.P of Uttar Pradesh while only one district lying in western U.P. Six districts fall into low category while fifty-five districts belong to medium category. **Figure** shows the distribution of cropping intensity among the four regions of Uttar Pradesh. The average net sown area as percent of total cropped area was found to be 65.4%. Highest cropping intensity was found in Bundelkhand (77%) followed by Eastern U.P (65.5%), Central U.P (65.4%) and Western U.P (62.2%). The possible cause of decline in cropping intensity in western U.P could be the development of industrial sector while other regions are more focussed in primary sector.

#### **Net Irrigated Area as a Percent of Net Sown Area (Irrigation Intensity)**

Since monsoons characterize India, irrigation is crucial in advancing agriculture. It is a critical factor for agricultural growth. An uninterrupted and optimal provision of water improves agricultural output (Singh, Jasbir, 1974). Irrigation intensity is the ratio of the net irrigated area to the net seeded area, expressed as a percentage. **Figure** shows the spatial distribution of irrigation intensity among the districts of Uttar Pradesh. The average intensity of irrigation was found to be around 80.6%. The highest irrigation intensity was found in Western U.P while lowest was found in Bundelkhand covering around 55.7%. Nineteen districts fall into high category among which fifteen districts belongs to Western U.P while three districts belong to Eastern U.P and only one district belong to Central U.P. Bundelkhand was found to have five districts in low category while two in medium category. The irrigation intensity was found highest in Western U.P due to its agrarian development taken place in green revolution. Fig. 1 and 2 depicts the distribution of irrigation intensity in the regions of Uttar Pradesh.

#### **Length of Canal per 1000ha of Net Sown Area**

Irrigation has been employed to facilitate the cultivation of crops, upkeep of landscapes, and restoration of flora in arid regions during periods of insufficient precipitation. Irrigation in India includes a comprehensive network of primary and secondary canals derived from Indian Rivers. Additionally, it involves the utilization of groundwater well-based systems, tanks, and other rainwater-gathering projects for agricultural purposes. Among these methods, the groundwater system

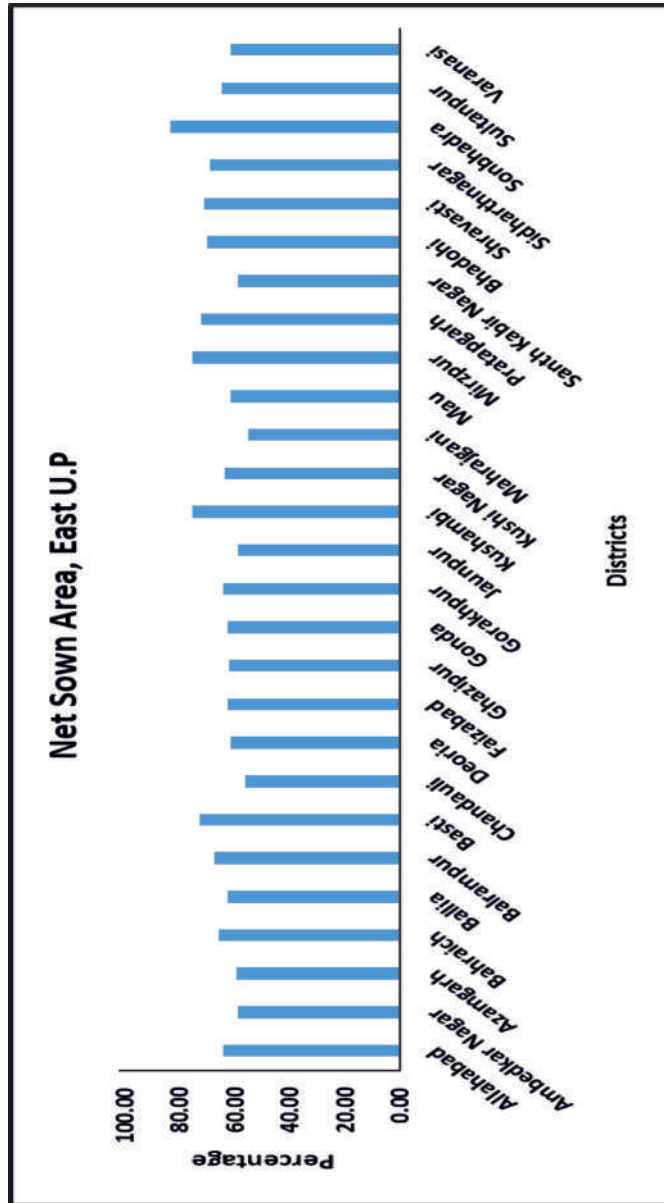


Fig. 3

is the most extensive (Siebert et al., 2010). Canal irrigation refers to constructing artificial channels that transport water from rivers or lakes to farms for irrigation. Ten districts fall into high category while four were found in low category. The distribution of canal irrigation was found almost similar in all over Uttar Pradesh. The average canal length per 1000ha of net sown area was found around 0.15km (Fig. 4). It was found highest in Bundelkhand (0.2km) followed by Central U.P (0.19km), Eastern U.P (0.16 km) and Western U.P (0.12km).

### **Consumption of Fertilizers Per ha. of Total Cropped Area**

Indian agriculture has the crucial task of providing sustenance to over a billion individuals, animals, and agro-based enterprises. To meet this requirement, it is essential to utilize contemporary inputs to enhance crop output. A significant proportion of small and marginal farmers within the population characterizes Indian agriculture. They frequently need more financial means to utilize capital inputs such as machinery and tractors and embrace innovative technologies for agricultural production. They encounter resource limitations, and the land size could be more economically viable, too. They have the option of using consumable contemporary inputs to increase land production. Among these consumable inputs, fertilizers are the sole input contributing to the increase in yield. There are five districts were found to have high consumption of fertilizers while four districts were in the low category of fertilizer consumption. The average consumption of fertilizer was estimated around 185.7kg per hectare of total cropped area. The highest consumption was found in Western U.P (222.3 kg/ha of total cropped area) followed by Central U.P (195.1 kg/ha of total cropped area), Eastern U.P (175.3 kg/ha of total cropped area) and Bundelkhand (71.3kg/ha of total cropped area). Three districts from Western U.P (Moradabad, Ghaziabad and Farrukhabad) were found to have highest consumption of fertilizers while only one district from Central U.P (Kanpur nagar) and Eastern U.P (Varanasi).

### **Per Cultivator Net Sown Area**

In Uttar Pradesh, the average net sown area available per person was approximately 1.01 hectares. Central Uttar Pradesh had the most extensive per capita net sown area, 1.32 hectares, compared to Bundelkhand's 1.3 hectares, East Uttar Pradesh's 0.96 hectares, and West Uttar Pradesh's 0.87 hectares. Two districts from West Uttar Pradesh (Agra) and Central Uttar Pradesh (Lakhimpur Kheri) were discovered to have a net sown area of less than two hectares per person.

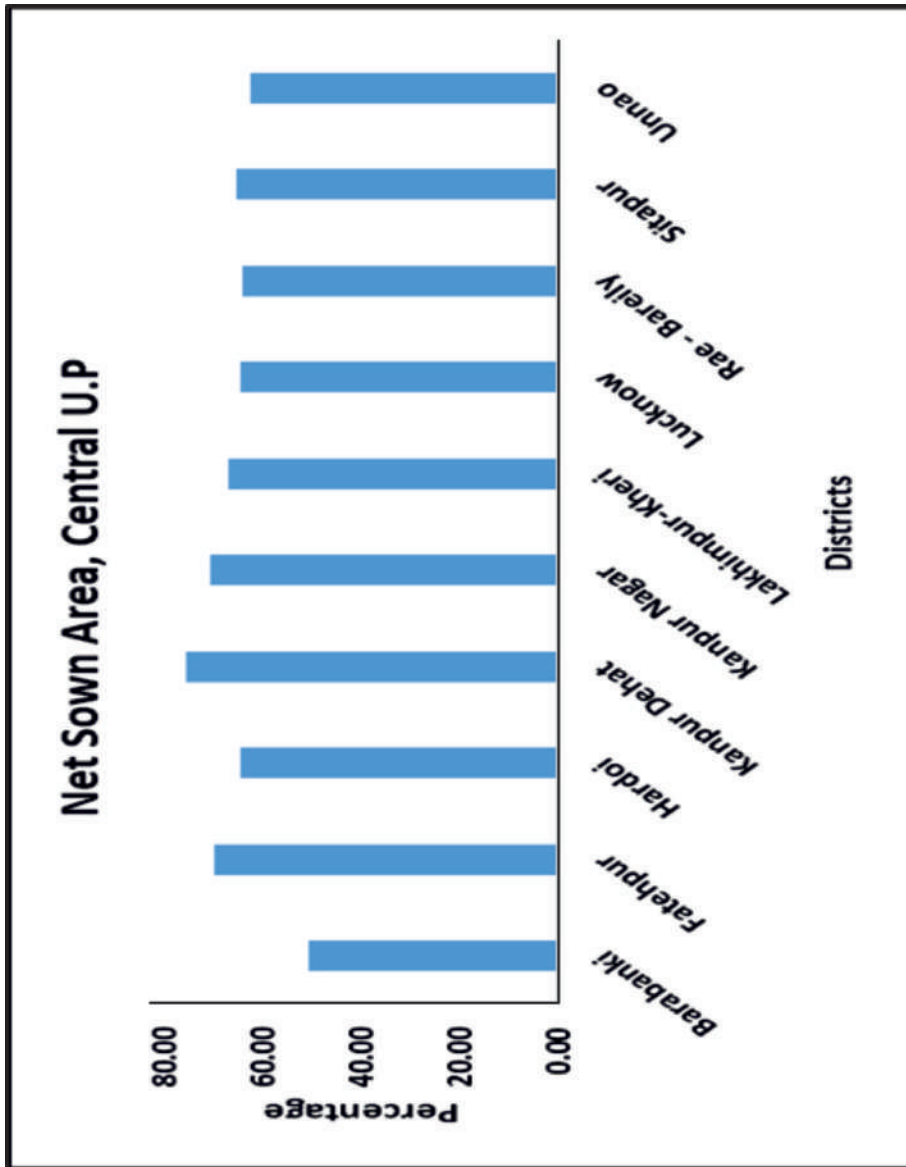


Fig. 4

In contrast, three districts from East Uttar Pradesh (Azamgarh, Bahraich, and Mirzapur) were found to have more than two hectares per person. Fifteen districts were discovered to have a net sown area per capita of less than half a hectare. These districts are Auraiya, Bagpat, Basti, Farrukhabad, Ghaziabad, Hathras, Kannauj, Kushambi, Mainpuri, Mau, Meerut, Moradabad, Sant Kabir Nagar, Sant Ravi Das Nagar, and Shravasti.

### **Conclusion**

The average proportion of net sown area to total cropped area was determined to be 65.4%. The region with the highest cropping intensity was Bundelkhand, with a rate of 77%. Eastern U.P followed this with a rate of 65.5%, Central U.P with a rate of 65.4%, and Western U.P with a rate of 62.2%. The potential reason for the decrease in cropping intensity in the western U.P. is attributed to the growth of the industrial sector. The mean irrigation intensity was determined to be approximately 80.6%. The Western U.P had the highest irrigation intensity, while Bundelkhand had the lowest, covering approximately 55.7%. The mean canal length per 1000 hectares of cultivated land was approximately 0.15 kilometres. The maximum occurrence was seen in Bundelkhand at a distance of 0.2 kilometres. The mean fertilizer use was estimated to be approximately 185.7 kilograms per hectare of the cultivated area. The Western U.P had the most significant consumption rate of 222.3 kg/ha of total cultivated area. The average per capita net sown area in Uttar Pradesh was roughly 1.01 hectares. The study shows the level of development in the districts of Uttar Pradesh as well as in the regions also. It shows Western U.P has better condition in agriculture due to advancement in infrastructure facilities like better irrigation facility with fertilization consumption.

### **References**

- Bhalla, G.S. & Tyagi, D.S. (1989). *Pattern in Indian Agriculture Development: A District Level Study*. New Delhi: Institute for Studies in Industrial Development.
- Jain, G.L. (2010). *Indian Agricultural Development*. Jaipur: Shree Niwas Publications.
- Panwar, Rajdev. (2016). *Land & Water Conservation: Need of the Hour*. Kurukshetra, 64(05), March, 31
- Guha, S., & Chandra, H. (2021). Measuring disaggregate level food insecurity via multivariate small area modelling: evidence from rural districts of Uttar Pradesh, India. *Food Security*, 13, 597-615. <https://doi.org/10.1007/s12571-021-01143-1>
- List of Districts of Uttar Pradesh. (n.d.). List of Districts of Uttar Pradesh. <https://nriol.com/india-statistics/uttarpradesh/districts.asp>

- Lata, S., & Lata, S. (2019). Profile of the Study Area: Uttar Pradesh. Irrigation Water Management for Agricultural Development in Uttar Pradesh, India, 21-47. [https://doi.org/10.1007/978-3-030-00952-6\\_2](https://doi.org/10.1007/978-3-030-00952-6_2)
- CGWB (2016) Ground Water Year Book Uttar Pradesh (2015–2016), G.o.I., Ministry of Water Resources. Retrieved from <http://cgwb.gov.in/Regions/GW-year-Books/GWYB-2015-16/GWYB%20NR%202015%20-%202016.pdf>

--Ahmad Mujtaba Siddiqui  
Assistant Professor  
Department of Geography  
Aligarh Muslim University  
Aligarh (Uttar Pradesh)

--Tariq Mahmood Usmani  
Professor  
Department of Geography  
Aligarh Muslim University  
Aligarh (Uttar Pradesh)

--Afia Aslam  
Research Scholar  
Department of Geography  
Aligarh Muslim University  
Aligarh (Uttar Pradesh)

## Four Year Subscription Form for Individual and Library

To,  
Secretary General,  
Deccan Geographical Society of India

Sir/Madam

Kindly enroll subscription for “The Deccan Geographer Journal”. Rs. 4000/-(Four Thousand only) is paying for four Year Subscription (2024-27). I abide the By-laws and rules of the society.

Name of Librarian/Prof.: .....

Cell No.: ..... Email: .....

Mailing Address: .....

..... Pin Code: .....

Date: ..... Place: .....

UTI No. .... Date: .....

Yours Sincerely  
Signature of Applicant

### Subscriptions Rate

Individual (Four Years) : Rs. 4,000/-  Library (Four Years) : Rs. 4,000/-  
 Foreigner Member (One Year) : US\$ 200/-  Foreigner Member (Four Year) : US\$ 1,000/-

### Payment by Online

**Account Name:** The Deccan Geographical Society, India

**Bank Name:** Bank of Maharashtra **Branch:** University of Pune

**Savings Account No.:** 60002473706 **IFSC Code:** MAHB0001355

**Note: (1)** Screenshot of Online payment should be sent by mail to Dr. B C Vaidya

**(2)** Demand Draft should be drawn in favor of ‘**The Deccan Geographical Society**’  
payable at New Delhi/Pune

**Journal Subscription Address:** Dr. B. C. Vaidya, Secretary General, (New Delhi),  
BE-5B, DDA Flats, Munirka, New Delhi-110067 (Email- vaidya2255@gmail.com)

Contact: - Dr. B. C. Vaidya (9560901219) / Dr. Sapna Sasane (9967650959)

**Society Address:** Dr. Sapna Sasane, Secretary General, (Pune HQ.), The Deccan Geographical,  
Department of Geography, Savitribai Phule Pune University, Pune-411007

(Maharashtra State) (E-mail: sapnasasane@yahoo.com)

# THE DECCAN GEOGRAPHICAL SOCIETY, INDIA

## DGSI Governing Council

### President

Professor K.N. Singh, Vice-Chancellor, Central University of South Bihar, Gaya (Bihar)

### Vice-President

Prof. W.G. Virulkar (Nagpur)  
Dr. Anita Pande (Nanital)  
Dr. Y. V. Krishnaiah (Agartala)

Prof. Kiran Kumari (Gaya)  
Dr. Parag Khadke (Nanded)  
Dr. Ashwajeet Chaudhary (Prayagraj)

Dr. Sachin Deore (Pune)  
Dr. N. Chendrayudu (Tirupati)

### Secretary General

Dr. B. C. Vaidya (New Delhi) and Dr. Sapana Sasane (Pune Headquarter)

### Secretary

Dr. Shivaji Pacharane (Pune), Dr. Mohd. Sarfaraz Asgher (Jammu), Dr. Ramesh Gavitt (Mumbai), Dr. Sheetal Shukla (Ahmadabad), Dr. Vishwa B. S. Chandel (Chandigarh), Dr. Jayashree (Mysuru), Dr. Dasharatha P. Angadi (Manglore)

**Treasurer:** Dr. Ravindra Shinde (Pune)

**Foreign Advisor:** Bimla Kumari (Kharsanki)

### Academic Co-ordinators

Dr. Anshu (New Delhi), Dr. Vimal Khawas (New Delhi), Dr. Jitendra Shukla (Ranchi), Dr. Rashmi Rani Anand (New Delhi) Dr. Purva Yadav (New Delhi) Dr. Nitasha Malhotra (New Delhi), Dr. Amrita Bajaj (New Delhi), Dr. Preeti Tewari (New Delhi), Dr. Anjana Mathur Jagmohan (New Delhi),), Dr. Sanjay Patil (Pune), Dr. M.L. Meena (Mahendragarh), Dr. CM. Meena (New Delhi), Dr. Kaveri Dabhedkar (Bilaspur), Dr. Uma Gole (Raipur), Dr. Sadhana Deshpande (Nagpur), Dr. T. Anuradha (Hyderabad), Dr. Suresh Phule (Latur), Dr. Nilanjana Dasgupta Sur (New Delhi), Dr. Syed Zaheen Alam (New Delhi), Dr. Som Nath Thakur (Noida)

### Executive Council Members

Prin. Anita Awati (Ratnagiri), Dr. Sajay Patil (Jalna), Dr. Vinod Veer (Wai), Dr. Arun Kumar Dwivedi (Lucknow), Prof. Ajay Gawari (Pune), Dr. Ganesh Madhe (Pune), Dr. Mahendra Korade (Junnar), Dr. Megha Sawarkar (Nagpur), Dr. Nilesh Kale (Lonavala), Dr. Vilas Kamble (Pune), Dr. Praveen Shinde (Pune), Dr. Deepali Chahande (Nagpur), Dr. Lalit Singh Jhala (Jodhpur), Dr. Sunil Akhare (Amravati), Dr. Gopal Sonkar (New Delhi), Dr. Deshraj Meena (New Delhi), Dr. Anupama Kamble (Raigad), Singh College), Dr. U.T. Gaikwad (Latur), Dr. Dheerendra Singh (Jaipur), Dr. Navneet (New Delhi), Dr. Kapil Kumar (New Delhi), Dr. Priyanka Gupta (New Delhi), Dr. Shalini Sikka (New Delhi), Dr. Ambesh Pande (Bhubaneshwar), Dr. B. Jat (Jaipur), Dr. Rahul Kumar (New Delhi)

### Advisory Board

Dr. Barkatullah Khan (New Delhi)  
Dr. B. Hema Malini (Waltaire)  
Dr. R.B.P. Singh (Patna)  
Dr. K.V. Chamar (Rohtak)  
Dr. Y.Y. Dudhpachare (Chandrapur)

Dr. A. R. Siddiqui (Prayagraj)  
Dr. V. Raghvaswamy (Hyderabad)  
Dr. Anuradha Sharma (Jammu)  
Dr. Amit Dhorde (Pune)  
Dr. Anuradha Sharma (Jammu)

## Subscriptions to ‘The Deccan Geographer Journal’

- Individual (Four Years) : Rs. 4,000/-  Library (Four Years) : Rs. 4,000/-
- Foreign Member (One Year) : US\$ 200/-  Foreign Member (Four Years) : US\$ 1,000/-

### Payment by Online/Demand Draft

**Account Name:** The Deccan Geographical Society, India

**Bank Name:** Bank of Maharashtra **Branch:** University of Pune

**Savings Account No.:** 60002473706 **IFSC Code:** MAHB0001355

**Note:** (1) Screenshot of Online payment should be sent by mail to Dr. B C Vaidya

(2) Demand Draft should be drawn in favor of ‘**The Deccan Geographical**

**Society**’ payable at New Delhi/Pune

---

**Journal Subscription Address:** Dr. B. C. Vaidya, Secretary General, (New Delhi), BE-5B, DDA Flats, Munirka, New Delhi-110 067 Email- [vaidya2255@gmail.com](mailto:vaidya2255@gmail.com)

**Contact:** - Dr. B. C. Vaidya (9560901219) / Dr. Sapana Sasane (09967650959)

**Society Address:** Dr. Sapana Sasane, Secretary General, (Pune HQ.), The Deccan Geographical, Department of Geography, Savitribai Phule Pune University, Pune- 411007  
(Maharashtra State) (E-mail: [sapnasasane@yahoo.com](mailto:sapnasasane@yahoo.com))

**Website:** [thedeccangeographer.com](http://thedeccangeographer.com)