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# POPULATION GEOGRAPHY

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## Association of Population Geographers of India

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## From the Editor's Desk

**In Memoriam**
**Gopal Krishan, President APGI, who left the worldly world on November 7, 2023**

**Nina Singh**

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# Urban Growth Dynamics in Gurugram Metropolitan Area: The Question of Sustainability

**Binu Sangwan and Jitendra Kumar[1]**

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**Abstract**: Gurugram, previously Gurgaon, a city situated south of New Delhi, the national capital of India and sharing its boundary with it, has experienced a tremendous growth trajectory from a Municipal Committee in 1961 to becoming Gurugram Metropolitan Area in 2017. Commensurately, the area expanded from 5.18 km² to 244.9 km², and its population went up from 38 thousand to nearly 2.4 million. The growth has been particularly phenomenal since the post-reform period. The built-up area of its constituent units in 2022 was 65.6 per cent in Municipal Corporation, Gurugram, 46.8 per cent in Municipal Corporation, Manesar and 16.9 per cent in rural areas. The metropolitan area includes approved and unapproved sectors/colonies/localities, outgrowths, census towns, several revenue villages with settlements within the Lal Dora, and large tracts of recently incorporated undeveloped land. What explains the urban dynamics? Is this growth sustainable to drive transformative change? This question is addressed in light of cities' physical and demographic growth being faster than the planning process, which poses a severe challenge for urban planners. Data sources are derived and mapped using Sentinel-2 and census data. The analysis reveals a mix-bag of centripetal and centrifugal forces linked with globalisation, industrialisation and economic development in bringing about this massive change within the city. Naturally enough, this explosive growth has brought concerns around sustainability in its wake.

***Keywords:*** urban expansion, sustainability, Gurugram Metropolitan Area, Municipal Corporation, Sentinel-2 data

India experienced a new phase of enhanced urbanisation in the post-liberalisation, privatisation, and globalisation period initiated in 1991. Concomitant urban expansion brings substantial social, economic and environmental transformations. Equally significant is that the urban places are more sustainable and equitable, and for that, they must be planned to protect and sustain all, leaving

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no one behind. Only such places can be leveraged in the fight against poverty, inequality, unemployment, climate change and other pressing global challenges. Sustainable urbanisation drives transformative change (United Nations Human Settlements Programme, 2020; 2022).

Urban expansion, extensively studied in geography and urban planning, refers to the process of urban growth that frequently results in the extension of urban development into rural areas and the conversion of farms and natural land into urban areas. It has positive and negative impacts on the environment, economy, and society. Positive impact includes economic growth (Deng et al., 2010; Li et al., 2020; Mahtta et al., 2022; Xie et al., 2020) that can lead to an increase in investment, job opportunities, and overall economic growth, particularly in the service sector, construction of new roads (Zhao et al., 2017; Shi et al., 2019; Maity et al., 2021) that improve the access of essential services. The negative impact contains environmental degradation (Redman & Jones, 2005; Mundia & Aniya, 2006; Wei & Ye, 2014; Imbrenda et al., 2021), shortage of housing (Chadchan & Shankar, 2012; Abhay & Sharma, 2022), traffic congestion (Zhao et al., 2010; Amezquita et al., 2021; Lu et al., 2021), loss of agricultural land (Fazal, 2000; Shi et al., 2016; Sumari et al., 2017; Radwan et al., 2019), coastal ecosystems (Lu et al., 2015), work-travel distance (Zhang et al., 2009) etc. Urban expansion has also been correlated with different dimensions like rail transport (Kheyroddin & Ghaderi, 2022), urban sustainability (Soliman & Soliman, 2022), urban heat island (Haung et al., 2015 and Zhao et al., 2016), football games (Brown & Lanci, 2016), land tenure security (Agegnehu et al., 2016), flood risk (Kasim et al., 2021), cost-benefit analysis (Lichfield, 2007) etc.

The truism is that city expansion in a developing nation like India often does not conform with the city's master plan or planning authorities. Often, growth is outside a city's administrative boundary, resulting in a lack of efficient land use planning and infrastructure on its outskirts (Hall, 2020). At the same time, satellite towns surround large metropolitan areas in India, lessening the population burden on the central city and providing access to affordable property to the city inhabitants and in-migrants. Several cities have developed around Delhi, the national capital, following a policy of decentralising industry from the city centre to the periphery (Krishnan, 2021). The process has reduced crowdedness and congestion in the national capital. These cities require efficient characterisation of the urban environment to support urban planning and management. With the advancement of geospatial technologies, time-series imaging in conjunction with an Earth Observation (EO) big data cloud computing platform can efficiently and affordably monitor urban growth (Yan, 2021).

The present work is focused on the Gurugram Metropolitan Area, a conspicuous example of intense urban growth in the post-liberalisation period, particularly since the turn of the century, which has been visualised spatially and demographically over the last three decades.

## Methodology

Gurugram Metropolitan Area, notified in 2017, has grown through the areal extension and accretion of municipal corporations, census towns, outgrowths, and *Abadi village or abadi deh*[2] *(inhabited area)*. This paper aims to understand the growth dynamics and raise issues of its sustainability. The Gurugram Metropolitan Area land use/land cover (LULC), 2022, was derived from ESA Sentinel-2 imagery at a 10m resolution (Figure 4). It is the best choice for LULC mapping because of its high spatial, spectral, and temporal resolution. Census is referred to for people-related information.

### Study Area

Gurugram Metropolitan Area covers 675 km² and is located near the Delhi-Haryana border on National Highway 48, just four kilometres from Indira Gandhi International Airport. It appears to be part of a big conurbation seen aerially. This metropolitan area includes the Municipal Corporations of Gurugram and Manesar and rural areas (Figure 1, on the following page)

Gurugram Municipal Corporation, a major constituent of the Gurugram Metropolitan Area, is one of the prominent cities of NCR besides Delhi, Faridabad, Ghaziabad, and Noida. Gurugram, also known as the country's cyber city, is a million city and one of the country's leading industrial and financial hubs. Business parks house the country's largest IT and Fortune 500 companies. Concomitant to this is growth in the real estate, automotive, and retail sectors.

Similarly, Manesar is one of India's fastest-growing industrial towns. Initially, it was developed as Industrial Model Township (IMT).

The Gurugram municipality is comprised of around 1119 localities/colonies. HSVP (Haryana Shehri Vikas Pradhikaran) sectors, group housing, builders' societies, the land around villages, and village settlements within Lal Dora, i.e., village *abadies* (Table 1).

**Table 1**

*Approved and Unapproved Areas/Units in Gurugram Municipality*

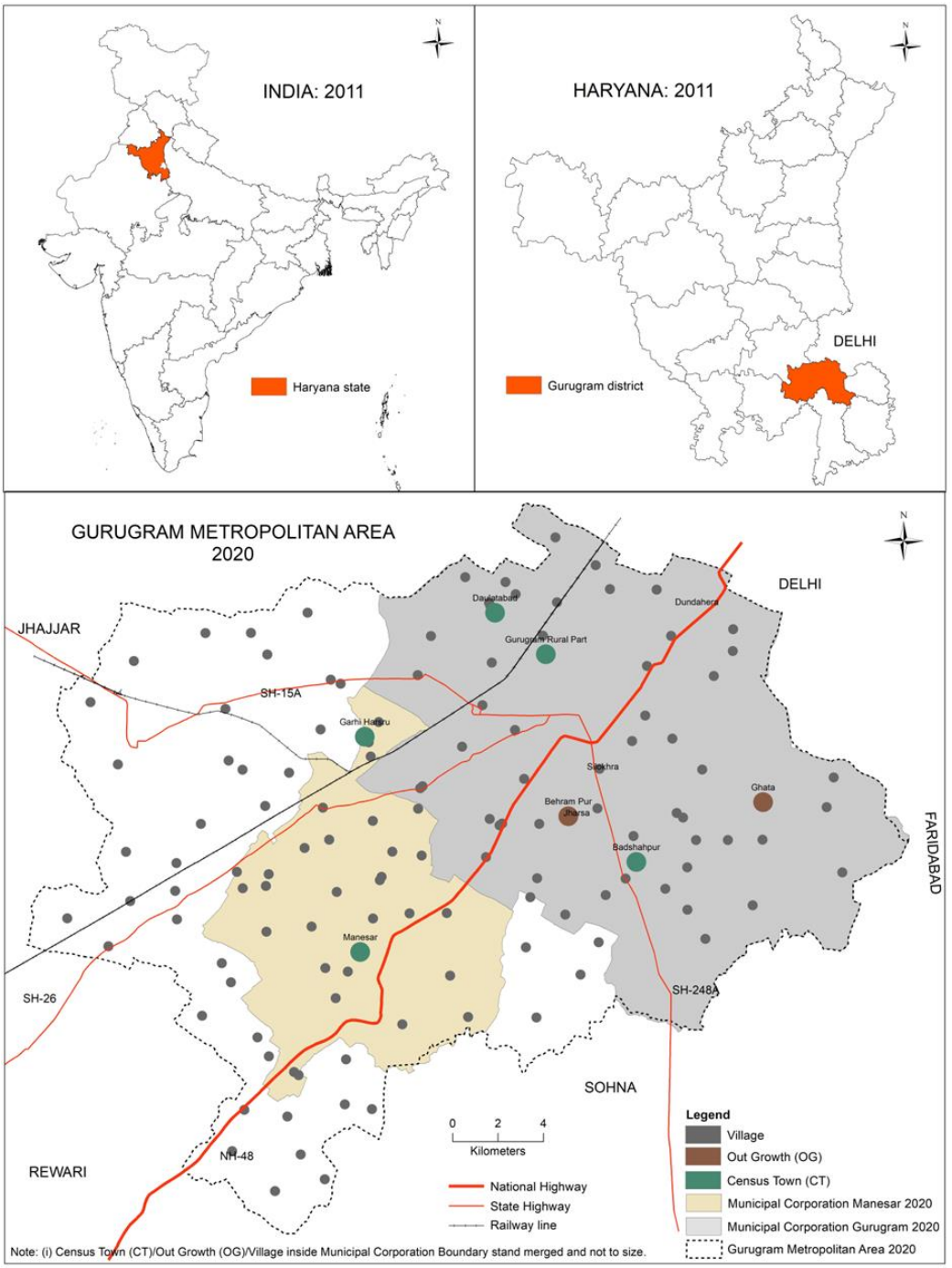
| Locations | | | Units |
|---|---|---|---|
| Approved | | | 804 |
| Unapproved | | | 315 |
| | (i) | Unapproved sector | 91 |
| | (ii) | Unapproved villages/societies/colonies etc. | 166 |
| Lal Dora | | | 58 |
| Total | | | 1119 |

Source: https://ulbhryndc.org

[2] 'Abadi Deh' or 'Abadi Village' is a term used in India to describe the areas within a village where houses and other buildings are located. These lands are mainly used for residential purposes and are usually considered outside agricultural or commercial land.

**Figure 1**

*Gurugram Metropolitan Area Geographic Location in India and Haryana State*




Source: Based on Census Data of 2001-2011 and Haryana Government Town and Country Planning Department Notification No. T&CP/GMDA/PF-89-III/2017/19918 dated 12 August, 2017.

## Urban Growth Dynamics: Analysis and Discussion

### Areal Expansion and Population Increase

The urban growth in Gurugram Metropolitan Area results from the growth pattern of its constituent units: The Municipal Corporations of Gurugram (the major constituent), Manesar, and the incorporated village *abadis*. The growth is the outcome of natural increase, jurisdictional change, and, in large measure, migration.

Gurugram, a Municipal Committee since 1961, transited to the Municipal Council in 2001 and Municipal Corporation in 2011, as per the Census.

> "The Haryana Municipal (Amendment) Act, 1994 (http://secharyana.gov.in/html/act5.htm) identifies "Municipality" as an institution of self-government constituted under section 2A, which may be a Municipal Committee, Municipal Council, or Municipal Corporation.
> 1) Municipal Committee is a transitional area with a population not exceeding fifty thousand;
> 2) Municipal Council is a smaller urban area with a population exceeding fifty thousand but not exceeding three lakhs, and
> 3) A Municipal Corporation is a larger urban area with a population exceeding three lakhs that is to be governed by a separate Act."

The change in its administrative status, coupled with the merger of Outgrowths– Silokhra, Jharsa; Census towns–- Gurgaon Rural, Dundahera, Sukhrali; and villages led it to expand physically (Table 2). Some Census Towns grew in situ while others were part of urban agglomeration. The addition of these lateral spreads (peri-urban areas and outgrowths) to the urban population has been sizeable and significant since 1991. Some village settlements within the jurisdiction of the municipal corporations have grown too large (Figure 2). Offering affordable housing finds favour with migrants, which supports the city's economy in formal and informal ways.

**Table 2**

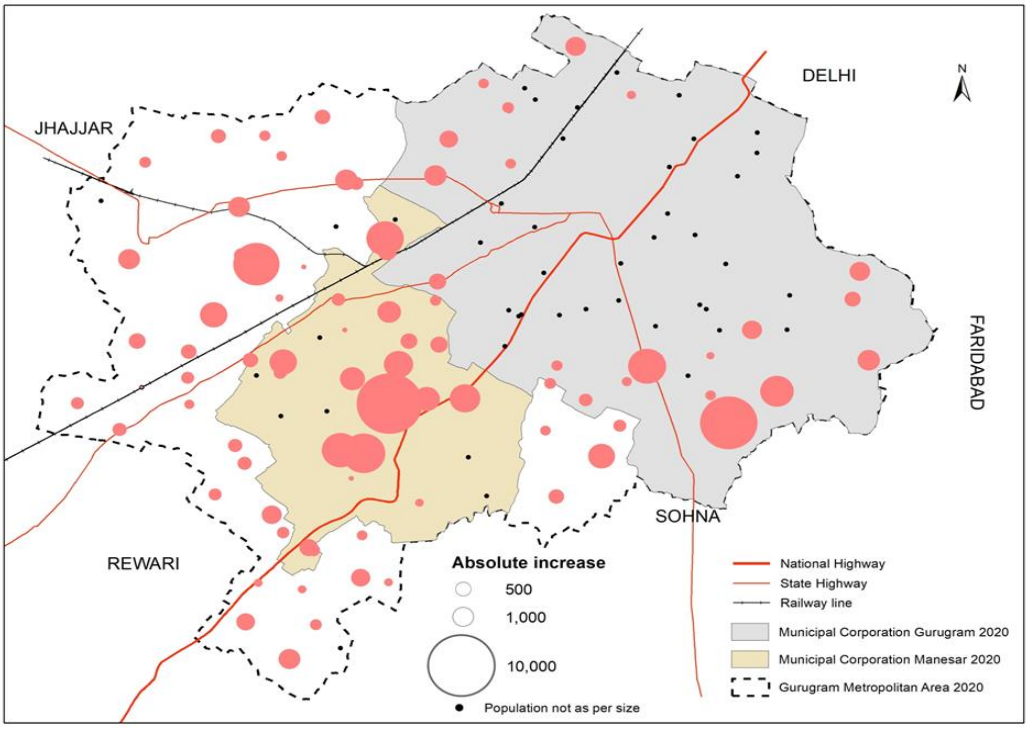
*Villages/Census Town Merged Into Gurugram Metropolitan Area*

| Year | Villages/Census Town | Area in sq. km | Population | Gurugram MC |
|---|---|---|---|---|
| 1971 | | | | 15.33 |
| 1981 | Gurugram Rural (CT) part | 8.80 | 11762 | 24.13 |
| 1991 | Dundahera (CT)<br>Gurugram Rural (CT) part | 5.75 | 21165 | 29.88 |
| 2001 | Silokhra (OG), Jharsa (OG)<br>Sukhrali (CT)<br>Gurugram Rural (CT) part<br>Dundahera (CT) | 17.51 | 66491 | 47.39 |
| 2011 | (i) (a) Daultabad (OG) Part, Ghata (OG) Part, Naya Behram Pur (OG) Part,<br>(b) Badshahpur Part (CT). | (a) 31.25<br>(b) 13.79 | 25142<br>15593 | Gurugram UA =198.39 sq. km. |

| Year | Villages/Census Town | Area in sq. km | Population | Gurugram MC |
|---|---|---|---|---|
| | (ii) Allawardi, Basai, Begampur Khatola, Behrampur, Cartarpuri Alias Daulatpur Nasirabad, Chakarpur, Choma, Dhanwanpur, Fazilpur Jharsa, Garoli Kalan, Garoli Khurd, Ghata, Islampur, Kadipur (Part), Kanahi, Khandsa, Kharki Dola, Mohammadpur Jharsa, Molahera, Nathupur, Pawala Khasrupur, Sarhol, Shamshpur, Sihi, Sikanderpur Ghosi, Tikri and Wazirabad. | 106.49 | 118888 | |

Source: (i) Computed from A-04: Towns and urban agglomerations classified by population size class in 2011 with variation between 1901 and 2011 - Class I. https://censusindia.gov.in/census.website/data/census-tables#
*Note: The projected population of 2021 is based on the Compound Annual Growth Rate (CAGR)

**Figure 2**
*Absolute Population Increase Between 2001-2011 in Gurugram Metropolitan Area Villages Notified by Haryana Government Town and Country Planning Department on 12.08.2017*




Source: Based on Primary Census Abstract Total, Haryana, District - Gurgaon – 2001 and 2011. https://censusindia.gov.in/nada/index.php/catalog/20695
https://censusindia.gov.in/nada/index.php/catalog/6277

Manesar, with a 14.7 sq. km area and 23448 people, emerged as a census town in 2011 with a state-of-the-art industrial model town (IMT). It was upgraded to a municipal corporation comprising 161 sq. km in 2020.

Similarly, a discernible change in population size happened. Gurugram Metropolitan Area's population figures were used to analyse growth trends and decadal variations from 1991 to 2021. The population has grown extraordinarily over the last three decades, from 0.36 million in 1991 to 1.17 million in 2011 and 2.42 million (projected, as the Census has not been held) in 2021 (Table 3). The decadal growth, recorded and estimated, was 67.9 per cent, 286.5 per cent, and 107.3 per cent commencing 1991. The population is expected to grow to 4.25 million by 2031, as per Gurugram Master Plan 2031.

Tracing Gurugram Metropolitan Area's population based on its area jurisdiction in 2020 shows a considerable change. The rural-urban components' configuration has shifted in favour of urban in terms of population and area (Table 3; Table 4).

**Table 3**

*Population Trends in the Gurugram Metropolitan Area From 1991-2021*

| Gurugram Metropolitan Area | Total population | | | | Per cent share | | | |
|---|---|---|---|---|---|---|---|---|
| | 1991 | 2001 | 2011 | 2021* | 1991 | 2001 | 2011 | 2021 |
| Rural | 226995 | 323392 | 241351 | 114842 | 61.41 | 57.46 | 20.68 | 4.75 |
| Urban | 142651 | 239446 | 925560 | 2303656 | 38.59 | 42.54 | 79.32 | 95.25 |
| Total | 369646 | 562838 | 1166911 | 2418498 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: (i) Computed from A-04: Towns and urban agglomerations classified by population size class in 2011 with variation between 1901 and 2011 - Class I.
https://censusindia.gov.in/census.website/data/census-tables# and
(ii) Primary Census Abstract Total, Haryana, District - Gurgaon – 2001 and 2011.
https://censusindia.gov.in/nada/index.php/catalog/20695
https://censusindia.gov.in/nada/index.php/catalog/6277
*Note: The projected population of 2021 is based on the Compound Annual Growth Rate (CAGR)

**Table 4**

*Gurugram Metropolitan Area (sq. km.), 2020*

| | Name | Administrative status | 1991 | 2001 | 2011 | 2020 |
|---|---|---|---|---|---|---|
| 1: 1A+1B+1C | Gurugram Metropolitan Area | Gurugram Metropolitan Development Authority | 675.0 | 675.0 | 675.0 | 675.0 |
| 1A | Gurugram | M. Corp | 29.9 | 47.4 | 198.4 | 310.3 |
| 1B | Manesar | M. Corp | ----- | ----- | 14.7 | 123.8 |

| | Name | Administrative status | 1991 | 2001 | 2011 | 2020 |
|---|---|---|---|---|---|---|
| **IA+IB** | **Gurugram + Manesar** | | **29.9** | **47.4** | **213.1** | **434.1** |
| | Per cent share of the urban area | | 4.4 | 7.0 | 31.6 | 64.3 |
| **1C** | **Rural Areas comprising villages** | | **645.1** | **627.6** | **461.9** | **240.9** |
| | Per cent share of the rural area | | 95.6 | 93.0 | 68.4 | 35.7 |

Source: Computed from Gurugram Metropolitan Area Map 2020 and Census of India Data 1991-2011.

A note on migration status would be appropriate since many people are migrants.

### *In-Migration in Gurugram City*

In Gurugram City, as per Census 2011, 71.6 per cent (6.45 lakh) people are migrants. Over 62.5 per cent (4.04 lakh) came in the nine years before 2011. An important aspect of interest is the volume of international migration. About 15456 or 2.4 per cent of persons were lifetime immigrants, mostly from Asian countries. Over 57.4 per cent (8875) of international migration was recorded in the nine years before 2011 (Table 5).

Within India, migrants are recorded as intra-state (intra-district, inter-district) and inter-state. 69.2 per cent of migration was inter-state, and the remaining was intra-state. The major source of interstate migration was from Delhi (1.32 lakh), followed by the three most backward states of India, namely Uttar Pradesh (1.1 lakh), Bihar (0.6 lakh) and Rajasthan (0.3 lakh) (Figure 3). Better work/employment and educational prospects, development of new industrial complexes, transport and communication and diversity of functions provided an impetus to facilitating migration in Gurugram.

**Table 5**

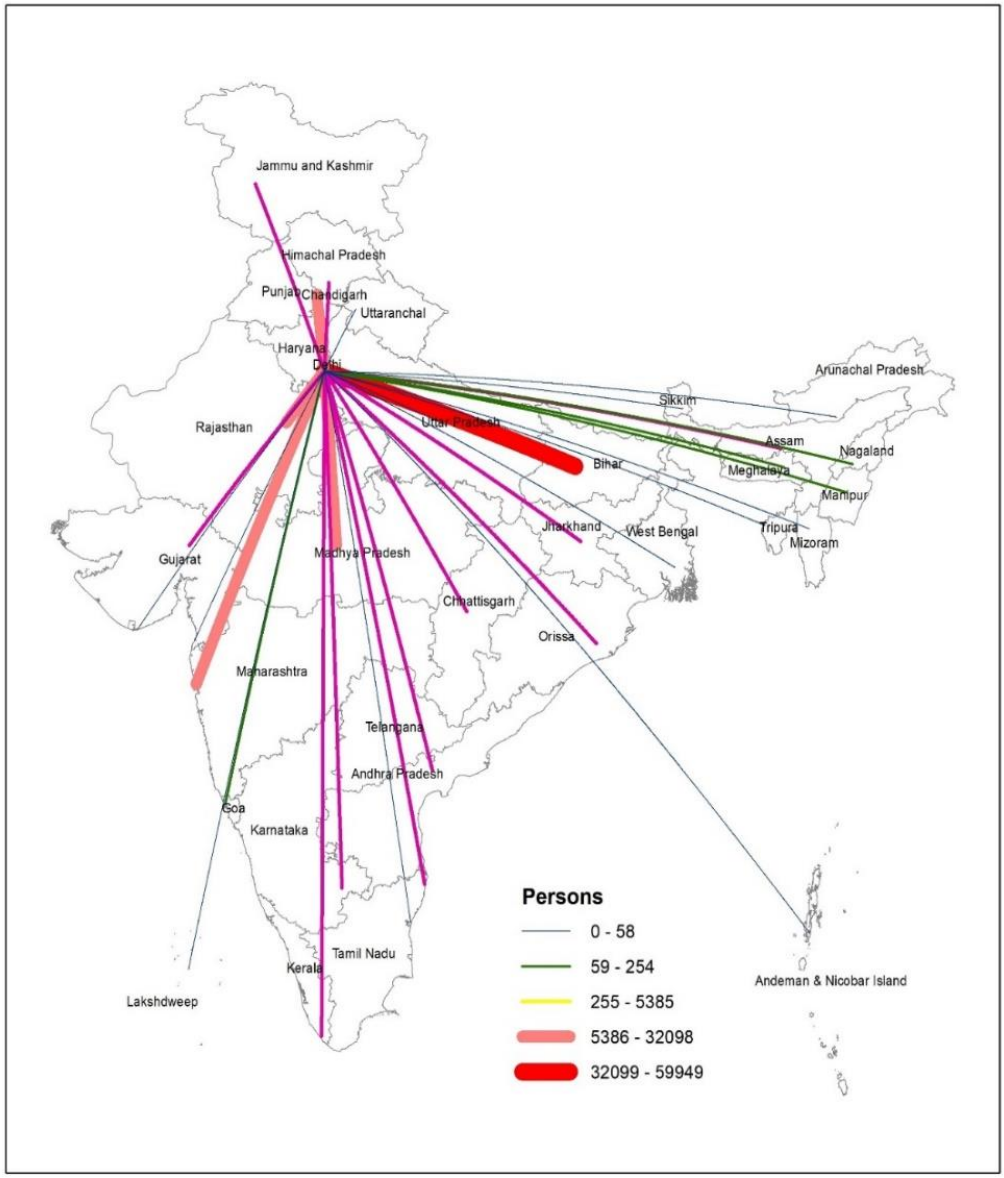
*In-Migration in Gurugram City, 2011*

| Type of Migration | Total migrants | Work/ employment | Business | Education | Marriage | Moved after birth | Moved with household | Total Others |
|---|---|---|---|---|---|---|---|---|
| Nomenclature | Numbers | Per cent migrants | | | | | | |
| **Total** | **6,45,568** | **30.05** | **0.98** | **0.56** | **13.50** | **2.37** | **41.67** | **10.88** |
| India | 6,29,885 | 30.09 | 0.98 | 0.56 | 13.71 | 2.39 | 41.66 | 10.60 |
| International | 15,456 | 28.24 | 1.15 | 0.56 | 4.68 | 1.24 | 42.01 | 22.12 |
| Unclassifiable | 227 | 32.16 | 0.88 | 1.32 | 5.73 | 2.20 | 45.81 | 11.89 |
| **Within India** | | | | | | | | |
| A) Intra State | 1,82,906 | 19.78 | 0.93 | 0.70 | 21.63 | 3.44 | 37.27 | 16.26 |
| (i) Intra District | 78,312 | 14.23 | 0.83 | 0.62 | 15.86 | 5.76 | 35.37 | 27.33 |
| (ii) Inter-District | 1,04,594 | 23.93 | 1.00 | 0.75 | 25.94 | 1.71 | 38.70 | 7.96 |
| B) Inter-State | 4,46,979 | 34.32 | 1.00 | 0.51 | 10.48 | 1.96 | 43.45 | 8.29 |
| **Age 01-09 years** | | | | | | | | |
| **Total** | **4,03,636** | **34.50** | **1.03** | **0.69** | **9.45** | **2.01** | **45.37** | **6.95** |
| India | 3,94,575 | 34.43 | 1.02 | 0.69 | 9.58 | 2.03 | 45.35 | 6.90 |
| International | 8,875 | 37.42 | 1.26 | 0.81 | 3.84 | 1.25 | 46.22 | 9.19 |
| Unclassifiable | 186 | 33.87 | 0.54 | 1.08 | 4.30 | 2.69 | 46.77 | 10.75 |
| **Within India** | | | | | | | | |
| A) Intra State | 84,933 | 23.72 | 1.13 | 1.07 | 15.93 | 3.53 | 46.38 | 8.23 |
| (i) Intra district | 34,116 | 18.96 | 1.07 | 0.96 | 12.43 | 6.47 | 48.14 | 11.98 |
| (ii) Inter-District | 50,817 | 26.91 | 1.17 | 1.15 | 18.28 | 1.56 | 45.21 | 5.72 |
| B) Inter-State | 3,09,642 | 37.37 | 0.99 | 0.58 | 7.84 | 1.62 | 45.06 | 6.54 |

Source: Computed from D-03 City: Migrants within the State/UT by place of last residence, duration of residence and reason of migration – 2011. https://censusindia.gov.in/census.website/data/census-tables#

**Figure 3**

*Lifetime Migrants in Gurugram City, 2011*




Source: Based on D-03 City: Migrants within the State/UT by place of last residence, duration of residence and reason of migration – 2011.
https://censusindia.gov.in/census.website/data/census-tables#

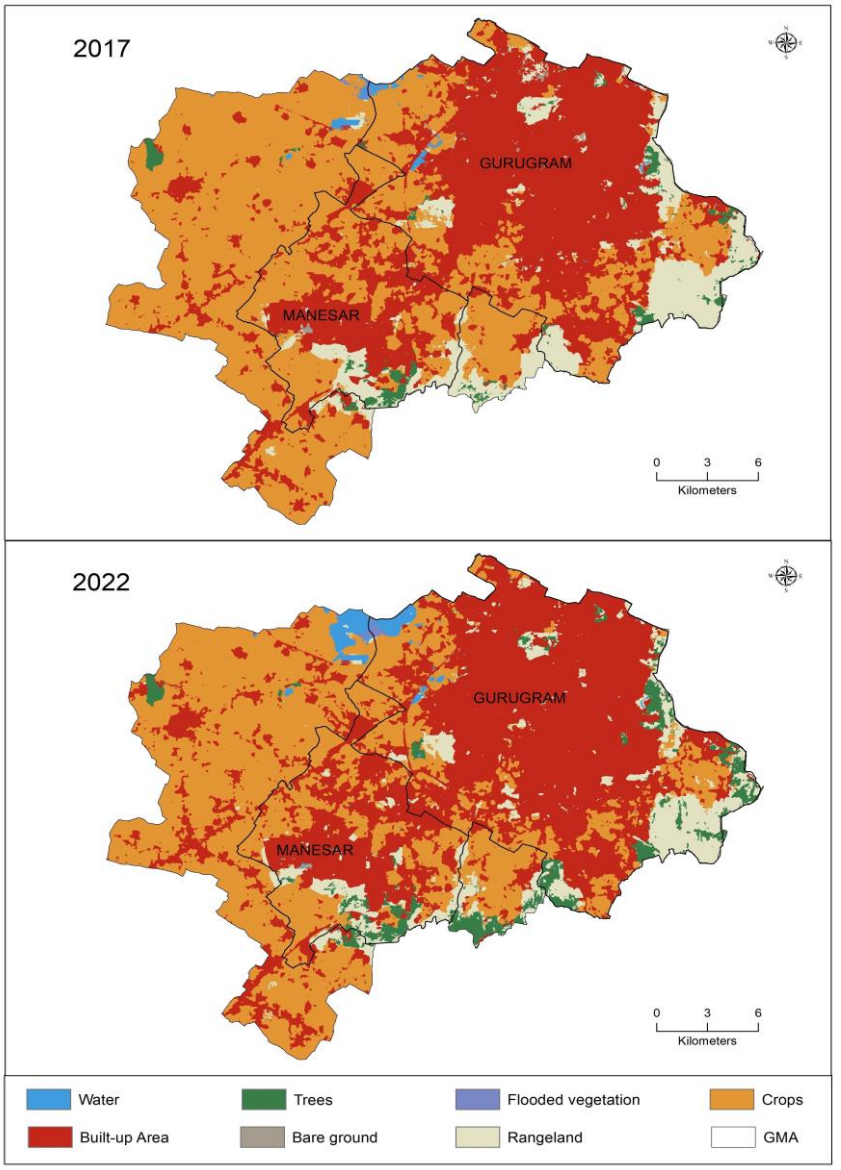
Consequently, upon peopling of the place, the built-up area increased.

### *Land-Use/Land-Cover of Gurugram Metropolitan Area*

Two-thirds of the MCG area and nearly fifty per cent of MCM fall under the built-up category in 2022; the change has been appreciable since 2017. All this has been at the cost of loss of cropland (Figure 4; Table 6).

**Figure 4**

*Land-Use/Land-Cover of Gurugram Metropolitan Area*




Source: Based on Sentinel-2 data downloaded from https://livingatlas.arcgis.com/landcoverexplorer/#mapCenter=-3.286%2C31.34%2C3&mode=step&timeExtent=2017%2C2021&year=2022&downloadMode=true

**Table 6**

*Land-Use/Land Cover of Gurugram Metropolitan Area and its Constituent Units, 2022*

| Land use/land cover category | GMA | | MCG | | MCM | | Rural Area | |
|---|---|---|---|---|---|---|---|---|
| | Area in sq. km | | | | | | | |
| | 2017 | 2022 | 2017 | 2022 | 2017 | 2022 | 2017 | 2022 |
| Water | 3.2 (0.5) | 8.7 (1.3) | 1.8 (0.6) | 3.4 (1.1) | 0.0 (0.0) | 0.1 (0.1) | 1.3 (0.6) | 5.2 (2.1) |
| Trees | 11.0 (1.6) | 25.9 (3.8) | 4.9 (1.6) | 13.5 (4.4) | 3.3 (2.7) | 5.0 (4.0) | 2.8 (1.2) | 7.4 (3.1) |
| Flooded vegetation | 0.6 (0.1) | 0.9 (0.1) | 0.2 (0.1) | 0.6 (0.2) | 0.0 (0.0) | 0.0 (0.0) | 0.4 (0.2) | 0.4 (0.2) |
| Crops | 333.7 (49.4) | 283.9 (42.1) | 77.4 (25.0) | 55.4 (17.8) | 58.5 (47.2) | 48.9 (39.5) | 197.8 (82.1) | 179.7 (74.6) |
| Built Area | 260.5 (38.6) | 302.0 (44.7) | 183.4 (59.1) | 203.5 (65.6) | 49.8 (40.2) | 57.9 (46.8) | 27.3 (11.3) | 40.6 (16.9) |
| Bare ground | 0.8 (0.1) | 0.4 (0.1) | 0.6 (0.2) | 0.2 (0.1) | 0.3 (0.2) | 0.2 (0.1) | 0.0 (0.0) | 0.0 (0.0) |
| Rangeland | 65.2 (9.7) | 53.0 (7.9) | 42.0 (13.5) | 33.7 (10.9) | 12.0 (9.7) | 11.7 (9.5) | 11.3 (4.7) | 7.6 (3.2) |
| Total | 675.0 (100) | 675.0 (100) | 310.3 | 310.3 (100) | 123.8 (100) | 123.8 (100) | 240.9 (100) | 240.9 (100) |

Source: Computed from Sentinel-2 data of 2017 and 2022.
Note: Figs. in parentheses indicate % area.
GMA: Gurugram Metropolitan Area
MCG: Municipal Corporation Gurugram
MCM: Manesar Corporation Gurugram

Globally, it has been observed that as the urban population increased, the land area occupied by cities increased at an even higher rate. Between 1990 and 2000, a global sample of 120 cities showed that while the population increased by 17%, the built-up area increased by 28%. By 2030, the urban population of developing countries is expected to double while the city area triples (World Cities Report, 2016).

Gurugram Metropolitan Area, comprising the Municipal Corporations of Gurugram and Manesar, covers 675.0 km$^2$. Growing as a satellite town of the National Capital, Gurugram has urbanised phenomenally since 1991 and more so since 2001. It is essentially a post-economic reform occurrence as it grew industrially, becoming a hub of multinational companies, industry giants, call centres, software companies, shopping malls and skyscrapers. Besides being home to one of India's largest medical tourism industries, it is also known for its thriving finance and real estate. The Gurgaon-Manesar-Dharuhera-Bawal belt offers plenty of opportunities for entrepreneurs.

The expanding number of people has exponentially increased the demand for housing, infrastructure, office, industrial, commercial, and residential space in the Gurugram Metropolitan Area. The fast urban growth has been the result of the policy to decongest the national capital industrially, the creation of the National Capital Region Planning Board in 1985 to plan the shift of economic activities from Delhi to neighbouring states and to develop regional centres' infrastructure, the New

Economic Policy introduced in 1991 which opened the country's economy to the world through liberalisation, privatisation, and globalisation and creation of infrastructure and institutional functions. Gurugram Metropolitan Area grew due to its proximity to the NCT of Delhi. It is also well-connected to other states via highways and expressways.

**The Question of Sustainability**

The city's expansion has significantly altered the land use/land cover patterns and brought about social, cultural and economic changes that are continually changing. The rapid and extensive land-use changes, coupled with explosive growth, have raised sustainability concerns. The Sustainable Development Goals (SDGs) for sustainable cities include aspects of urban planning, design, and management, as well as clean air, water, and soil. They also address affordable, inclusive, and accessible transport, climate mitigation, building resilience, and integrating the needs of the impoverished. The challenge lies in achieving economic and social development without compromising the environment while enhancing urban residents' overall quality of life and well-being.

The unprecedented growth of this magnitude has placed tremendous demands on resources such as housing, water, sewage, energy, mobility, and biodiversity, leading to the generation of substantial waste. People are experiencing highly polluted air, mobility crisis, high road accident risk, and providing liveable conditions for migrants. The continual increase in built-up areas demands commensurate upgrading of physical infrastructure and strengthening institutions with an eye on sustainability. After all, transformative change will only come with sustainable urbanisation.

To start, the urban development approach adopted by the Haryana government is characterised by a random nature of growth in the city. In 1975, the state government enacted the Haryana Development and Regulation of Urban Areas Act, amplifying the involvement of the private sector in real estate development.

This resulted in the private sector acquiring a vast expanse of agricultural land. The city sprang up randomly and rapidly with rampant flouting of planning and construction norms. Numerous water bodies within the city were reportedly filled to facilitate construction, resulting in the blatant degradation of the ecology. This can be discerned from the fact that Gurugram was a relatively small urban area that acquired the status of a city in 2001. It became a Municipal Corporation in 2008 and MCG in 2017. Gurugram Metropolitan area comprises planned and unplanned areas, village *abadis*, and sectors built by HSVPN and private builders.

The economic dynamism in the area has also brought in many migrants working in the formal and informal sectors. This surge has heightened the need for housing and other essential civic amenities, including water supply. Migrants working in the informal sectors and low-paid jobs abound in scores of village settlements and unauthorised areas for want of living space, tremendously increasing

pressure on resources in these unplanned areas. Supplying water connections to the expanding population in slums may challenge the authorities, as it adds to the strain on water resources that are already under pressure, along with the broader urban infrastructure. What strategies can be employed to attain economic and social development without causing harm to the environment, all the while enhancing the overall quality of life and well-being of urban residents? Need to be worked out.

Another Achilles' heel is the intricate web of multiple urban governance bodies in the city, operating amidst overlapping jurisdictions and inadequate coordination. This results in a lack of robust accountability and prolonged delays in identifying and implementing solutions. The governance structure in Gurugram has consistently been fragmented, with entities like HSVPN (Haryana Shehri Vikas Pradhikaran), the PWD of the Haryana State government, MCG, GMDA (Gurugram Metropolitan Development Authority), and private developers shouldering responsibilities for service provision in various parts of the city based on their respective jurisdictions. Consequently, this situation has given rise to infrastructure challenges in specific city areas.

The Water Sustainability Assessment of Gurugram City by TERI (2020, p.14) found that unregulated and chaotic expansion in and around Gurugram City has destroyed wetlands, vegetation, and drainage channels. Due to land topography changes to maximise real estate development in Gurugram, water bodies have declined rapidly. Lowlands, once home to *johads* (traditional names for ponds and lakes), now have structures. In the future, extensive development may strain land and water resources, altering resource availability and ecology. Encroachments, unauthorised construction, and improper municipal waste and construction debris disposal threaten ponds and lakes.

Groundwater extraction has increased drastically in Gurugram as real estate development has outpaced city planning and public infrastructure related to water supply. Additionally, rapid city population growth has created an imbalance between annual groundwater extraction and recharge levels, which will worsen if not controlled. An unknown number of illegal bore wells makes monitoring and controlling illegal extraction difficult. The increase in built-up area and population has depleted its groundwater resource, which was rated as overexploited at 100 per cent in 2022 (Government of India, October 2022, p.157). The stage of groundwater extraction was 213.14 per cent in 2022.

The city's residential housing market, along with commercial and institutional establishments, is expected to be the main consumer of water in the coming years as the built-up areas continue to grow. The Pataudi, Farrukh Nagar, and Sohna tehsils currently contain most of the area's agricultural land.

The intensity of flooding during monsoons is expected to escalate in Gurugram city, attributed to a diminished catchment area, reduction in water bodies and green cover, and the expansion of built-up land.

The Centre for Science and Environment (CSE) has published a report indicating that the rapid urbanisation in Gurugram leads to significant environmental and sustainability issues. Failure to address this issue during the initial phases of development may result in significant depletion of resources, which can have detrimental effects on the environment and public health.

To achieve the sustainable development goals, the Guidance Framework lays out a plan for Gurugram to more efficiently use its resources, conserve water, energy, materials, and biodiversity, recycle and reduce pollution and waste, and ensure that all residents have equal access to these resources. These goals aim to realise what the New Urban Agenda and the Sustainable Development Goals (SDGs) have set out to accomplish. They are based on best practices and reflect the vital tenets of resource efficiency and savings policies at the state and national levels.

**Conclusion**

The present study has traced and analysed the urban growth dynamics in the Gurugram Metropolitan Area, focussed on post-reform changes based mainly on sentinel-2 satellite data and Census data. Benefitting from its location bordering the national capital, the policy to decongest Delhi, and the policy of the state government to create infrastructure to boost industrial development with the adoption of the policy of liberalisation, privatisation, and globalisation in India, it experienced tremendous dynamism in urban growth and land transformation attributed to industrialisation and its 'embeddedness' in a global network as a hub of multinational companies' offices and the centre of economic vitality worldwide. The large-scale change is essentially a post-2001 phenomenon. The built-up areas are expected to increase continually to three-fifths of the total area. A shrink in vegetation cover to less than the norm and depletion of water bodies raise concerns in the wake of pressing global problems arising from climate change and pose a challenge to policymakers. The scenario calls for the timely intervention of the political dispensation, policymakers, administrators, environmentalists, and all stakeholders to adopt sustainable practices for better land use management, such as ‘green investment for sustainable patterns of consumption and production, responsive and inclusive urban planning, the prioritisation of public health, and innovation and technology for all’.

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# Understanding the Role of Education in the Age at Marriage of Women in India

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**Abstract:** Early marriage is linked to poor maternal and child health outcomes. Against this backdrop, this study addresses the role of women's educational attainment on their age of marriage in India. Data from 75,826 ever-married women aged 15-49 years gathered in the National Family Health Survey (2019-21) was analysed. Using Kaplan-Meier survival analysis and multivariate logistic regression models, we investigated associations among women's educational attainment and age at marriage. Women with higher levels of education had lower odds (OR=0.06,95%CI= 0.05 to 0.07) of getting married below 18. Women from the Scheduled Tribe (OR=0.70, 95%CI= 0.66 to 0.74) and Other Backward Classes (OR= 0.92, 95%CI= 0.88 to 0.96) were less likely to marry before 18 than those from the general caste. Odds of early marriage were again low among women from higher-income households. Postponing marrying until the girls reach 18 years necessitates ensuring that females attend school and complete secondary education.

***Keywords*:** age at marriage, educational attainment, ever-married women, India

Although child marriage has been significantly reduced, it is still widespread in sub-Saharan and South Asian nations. In South Asia, 285 million females under 18 are married, accounting for 44 % of the global load (UNICEF, 2018). For instance, although it has been illegal to marry before the age of 18 in India for over three decades, about half of all girls persist in doing so (Nguyen & Wodon, 2015). Early

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marriage promotes early childbirth, closed-spaced pregnancies, unintended pregnancies, and pregnancy loss (Adhikari et al., 2009). Early marriage and teenage pregnancies violate international human rights conventions and seriously endanger women's health, well-being, and future development (Psaki, 2016). Various adverse maternal outcomes are linked to early maternal reproduction in women. Low levels of education, poor growth, malnutrition, sickness, and mortality, particularly during childbirth, are a few of these. Children can also experience negative effects (Goli et al., 2015).

Despite implementing legislation and programs to stop the practice, girl-child marriage is still common in India (UNICEF, 2018). Women's education is frequently cited as the primary strategy for achieving the postponement of age at marriage. However, some recent research revealed that marriage patterns are changing globally, and developing nations are likewise no exception (Basu, 1998; Esteve & Cortina, 2006; Lloyd, 2005). Female education is a key program and policy component in lowering the frequency of early marriage among women (Svanemyr et al., 2012). In India, literate women rose from about nine per cent in 1951 to 66 % in 2011. Women can better decide on occupation, marriage, and family formation as their education levels rise. Girls who complete secondary or higher education significantly postpone getting married (Raj et al., 2014; Singh & Espinoza Revollo, 2016). Indians from various backgrounds adhere to rituals unique to their culture. As a result, marriage and kinship arrangements differ based on race, ethnicity, religion, and place of residence (Borkotoky & Gupta, 2016). More research has to be done on the factors that influence marriage patterns, particularly in India, where societal dynamics around marriage and mate choice are drastically changing. The most significant change has been a move from child to early teenage marriages, although many women continue to marry before reaching age 18 (Raj et al., 2014; Wodon et al., 2017).

In addition to schooling, several other potential factors, including economic standing, sociocultural and religious norms, the status of women's autonomy, and geographic residence, have a considerable impact on determining the age of marriage for women (Aryal, 2007, p. 701; Kamal, 2010; Kamal et al., 2015; Mathur et al., 2003; Nour, 2009; UNFPA, 2012). Past studies mainly focused on assessing early marriage's socioeconomic and demographic determinants at the individual and household levels. Furthermore, scant research has been done on the macro level about the association between educational attainment and teenage marriage among women. There are significant regional differences in education and economic standing in India. These challenges are particularly prevalent in India's east and central areas, where child marriage is still common. Therefore, this paper aims to examine the effects of schooling on the age of marriage of women in India.

## Data and Methods

### Study Population

We used data from the fifth round of the National Family Health Survey (NFHS-5) conducted in 2019-21 under the aegis of the Ministry of Health and Family Welfare (MoHFW), India. NFHS-5 is a nationally representative large-scale survey that covers all states and Union Territories of India. The survey covered 636,699 households, 724,115 women, and 101,839 men. The prime objective of NFHS is to provide reliable data on various health and family welfare issues, such as fertility, mortality, maternal and child health, sexual behaviours, and domestic violence. The NFHS-5 employed a two-stage stratified random sampling design for data collection (IIPS & ICF, 2021). Ever-married women aged 15-49 covered in the state module of the survey (n=75,826) were considered for the present analysis. This survey was conducted in conformity with internationally agreed-upon ethical norms for medical research. In the sampled households, an individual survey schedule was given to each consenting respondent. All procedures were carried out in conformity with the necessary standards and laws. All subjects and/or their legal guardian provided informed consent(s). The published survey report thoroughly describes the methodology, including details on the survey's design, data-gathering methods, ethical issues, and quality assurance procedures (IIPS & ICF, 2021). As this is an analysis of secondary data available in the public domain, no further ethical approval is necessary (https://www.dhsprogram.com).

### Outcome Variable

The prevalence of early marriage among women was the outcome variable in this study. It was measured as the proportion of ever-married women married below 18 years of age. Here, we have recoded the variable as '1' for those women who got married below 18 years of age and '0' for those women who married at 18 years and above.

### Exposure Variables

This study included relevant exposure variables suggested by existing literature (Delprato et al., 2017; Maitra, 2004; Male & Wodon, 2018; Marphatia et al., 2020). The variables were categorised into demographic and socioeconomic characteristics and factors related to women's empowerment status. This study identified women's educational attainment as the main explanatory variable. Women's educational attainment is categorised into five categories: i) no schooling, ii) 1-5 years, iii) 6-8 years, iv) 9-12 years, and v)13 and above years of schooling. Other socioeconomic factors included household wealth status (poorest, poorer, middle, richer, richest), mass media exposure (not exposed, exposed), women's occupation (not working, agriculture and other sectors), type of marriage (consanguineous, non-consanguineous), and women's autonomy. Women's

autonomy is crucial in their ability to make marriage-related decisions. We have built a women's autonomy index based on the information collected on household decisions, movement, and financial decisions. Confirmatory factor analysis derives a single construct behind the various dimensions of women's autonomy, and the index was categorised into terciles (low '0', medium '1', and high '2').

The demographic characteristics included were the current age of women (15-24, 25-34, and 35-49), caste (Scheduled Castes – SC, Scheduled Tribes- ST, Other Backward Classes – OBC, others), religion (Hindu, Others), place of residence (urban, rural) and region. Region variable was categorised into six groups: North (Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttarakhand), Central (Chhattisgarh, Madhya Pradesh, and Uttar Pradesh), East (Bihar, Jharkhand, Odisha, and West Bengal), Northeast (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura), West (Dadra & Nagar Haveli, Daman & Diu, Goa, Gujarat, and Maharashtra), and South (Andaman & Nicobar Islands, Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Pondicherry, Tamil Nadu, and Telangana)(IIPS & ICF, 2021).

## Statistical Analysis

Descriptive statistics were obtained, and the chi-square test was used to assess the association of selected background characteristics with the outcome variable. Additionally, the unadjusted and adjusted multivariate logistic regression was performed to analyse the association of age at marriage with selected background characteristics.

The equation for logistic regression is $l_n\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n$

Where $X_1, X_2, X_3, \ldots X_n$ are explanatory variables and $\beta_1, \beta_2, \beta_3, \ldots \beta_n$ are regression coefficients.

Appropriate national sampling weights were used in the analysis. The baseline model of the multivariate analysis included all the potential factors along with the outcome variable. The statistical analysis was done in Stata 16.1, and a significance level of $p<0.05$ was used. Additionally, Kaplan-Meier survival plots assessed the likelihood of women delaying their age of marriage stratified by women's educational level. Survival plots were assessed at the median ages (at a 95% Confidence Interval). These occurrences were experienced by women with various levels of education and women without education at all.

## Results

### Sample Profile

The detailed demographic, socioeconomic, and women's empowerment-related determinants of age at marriage are presented in Table 1. More than two-fifths (41%) of the women got married below 18 years, the legal age to marry in India. Of the respondents, 24% and 23% were from eastern and central regions. More than half of the respondents belonged to rural areas. Most (81%) women follow the Hindu religion. Almost 35% of women completed ten or more years of schooling. Among the respondents, three-fourths (75%) were exposed to mass media. More than half of the women were not currently working. Regarding domestic, financial, and health-related decision-making, just 10 % of women had higher autonomy. About 13% of the women were a blood relative to their spouses or partners before marriage.

**Table 1**

*Percentage Distribution of Ever-Married Women Aged 15-49 Years in India, 2019-21*

| Background Characteristics | Per cent | Number |
|---|---|---|
| Women's Marriage Age in Years | | |
| 18 and above | 58.8 | 44,547 |
| Less than 18 | 41.3 | 31,278 |
| Demographic Characteristics | | |
| Women's Current Age in Years | | |
| 15-24 | 16.9 | 12,789 |
| 25-34 | 37.9 | 28,746 |
| 35-49 | 45.2 | 34,291 |
| Caste | | |
| SC | 21.4 | 16,189 |
| ST | 9.1 | 6,905 |
| OBC | 43.8 | 33,210 |
| Others | 25.8 | 19,521 |
| Religion | | |
| Hindu | 81.1 | 61,521 |
| Others | 18.9 | 14,305 |
| Place of Residence | | |
| Urban | 31.0 | 23,516 |
| Rural | 69.0 | 52,310 |
| Region | | |
| North | 14.1 | 10,694 |
| Central | 23.0 | 17,437 |
| East | 24.3 | 18,388 |
| North-East | 3.8 | 2,843 |
| West | 14.1 | 10,706 |
| South | 20.8 | 15,758 |
| Socioeconomic Factors | | |
| Women's Education (years) | | |

| Background Characteristics | Per cent | Number |
|---|---|---|
| None | 27.5 | 20,882 |
| 1-5 | 13.7 | 10,394 |
| 6-8 | 16.7 | 12,645 |
| 9-12 | 29.1 | 22,060 |
| 13-20 | 13.0 | 9,845 |
| Wealth Status | | |
| Poorest | 18.7 | 14,170 |
| Poor | 20.3 | 15,410 |
| Middle | 20.5 | 15,573 |
| Richer | 20.4 | 15,491 |
| Richest | 20.0 | 15,182 |
| Women's Empowerment Status | | |
| Mass Media Exposure | | |
| Not Exposed | 24.7 | 18,758 |
| Exposed | 75.3 | 57,068 |
| Women's Occupation | | |
| Not working | 69.1 | 52,362 |
| Agriculture | 18.0 | 13,626 |
| Other sectors | 13.0 | 9,838 |
| Decision making autonomy | | |
| Low | 45.3 | 34,351 |
| Medium | 45.1 | 34,204 |
| High | 9.6 | 7,270 |
| Type of Marriage | | |
| Non-consanguineous | 87.3 | 66,190 |
| Consanguineous | 12.7 | 9,636 |
| Total | 100 | 75,826 |

**Prevalence of Marriage at Below Legal Age**

Prevalence and association of age at marriage below 18 years with some selected background characteristics among ever-married women are presented in Table 2**.** Factors significantly associated with the early marriage of women included educational attainment of women (years), current age, caste, religion, residence, women's occupation, and decision-making autonomy of women ($p<0.001$). The prevalence of early marriage was 41 % among ever-married women in the reproductive age group. The estimated prevalence of early marriage was 59 % in the case of uneducated women who never went to school in their lifetime. It is higher than those who had a certain level of education. Women from low-income households were more likely to marry before turning 18 than those from households with higher incomes. The prevalence of early marriage was 54 % among women not exposed to mass media. Forty-seven per cent of women involved in agricultural activities got married below 18.

**Table 2**

*Percentage Distribution of Women Aged 15 to 49 Years According to Marriage at Age Less than 18 Years by Selected Characteristics of Women in India, 2019-21*

| Background Characteristics | Marriage below 18 years (%) | Chi-square (p-value) | N |
|---|---|---|---|
| *Demographic characteristics* | | | |
| Women's current age in years | | | |
| 15-24 | 41.99 | <0.001 | 12,789 |
| 25-34 | 36.62 | | 28,746 |
| 35-49 | 44.85 | | 34,291 |
| Caste | | | |
| SC | 45.85 | <0.001 | 16,189 |
| ST | 44.59 | | 6,905 |
| OBC | 40.38 | | 33,210 |
| Others | 37.74 | | 19,521 |
| Religion | | | |
| Hindu | 41.56 | <0.001 | 61,521 |
| Others | 39.94 | | 14,305 |
| Place of residence | | | |
| Urban | 31.86 | <0.001 | 23,516 |
| Rural | 45.47 | | 52,310 |
| Region | | | |
| North | 32.86 | <0.001 | 10,694 |
| Central | 42.81 | | 17,437 |
| East | 52.04 | | 18,388 |
| North-East | 37.64 | | 2,843 |
| West | 36.58 | | 10,706 |
| South | 36.46 | | 15,758 |
| *Socioeconomic factors* | | | |
| Women's education in years | | <0.001 | |
| none | 58.60 | | 20,882 |
| 1-5 | 55.25 | | 10,394 |
| 6-8 | 47.63 | | 12,645 |
| 9-12 | 29.94 | | 22,060 |
| 13-20 | 6.83 | | 9,845 |
| Wealth Status | | | |
| Poorest | 54.88 | <0.001 | 14,170 |
| Poor | 50.12 | | 15,410 |
| Middle | 44.22 | | 15,573 |
| Richer | 35.3 | | 15,491 |

| Background Characteristics | Marriage below 18 years (%) | Chi-square (p-value) | N |
|---|---|---|---|
| Richest | 22.54 | | 15,182 |
| *Women's Empowerment Status* | | | |
| Mass Media Exposure | | | |
| Not Exposed | 53.54 | <0.001 | 18,758 |
| Exposed | 37.21 | | 57,068 |
| Women's Occupation | | | |
| Not working | 39.34 | <0.001 | 52,362 |
| Agriculture | 47.39 | | 13,626 |
| Other sectors | 42.90 | | 9,838 |
| Decision making autonomy | | | |
| low | 42.02 | <0.001 | 34,351 |
| medium | 41.62 | | 34,204 |
| high | 40.41 | | 7,270 |
| Type of marriage | | | |
| non-consanguineous | 40.80 | <0.001 | 66,190 |
| consanguineous | 44.35 | | 9,636 |
| Total | 41 | | 75,826 |

Forty-two per cent of the women got married below 18 in the case of women with low decision-making autonomy, compared to 40% of women with high decision-making autonomy. The prevalence of early marriage among women in the eastern region was 52 %, much higher than in other regions.

**Determinants of Age at Marriage Among Ever-Married Women in India**

Table 3 presents logistic regression results for the effects of different levels of education and other factors on the early marriage of women. Except for place of residence, all other factors considered in the regression model were predicted to influence women's early age at marriage significantly. The likelihood of early marriage decreased with rising levels of education among women. The percentage of women who marry before turning 18 was much greater for those with no formal education and only elementary schools (1–5 years). However, for women with secondary education of 6 to 8 years, the odds of being married early decreased (OR=0.65, 95% CI=0.62 to 0.68), followed by higher education of 9 to 12 years (OR=0.31, 95%CI=0.29 to 0.32), and 13 years or above (OR=0.06, 95% CI=0.05 to 0.07). Even after adjusting for every other variable, the impact of women's educational attainment remained consistent. Women aged 35 to 49 were less likely to marry before 18 (OR=0.78, 95%CI= 0.74 to 0.81) than those aged 15 to 24. The chances of getting married early on were lower for the women from ST (OR=0.70, 95%CI= 0.66 to 0.74) and OBC (OR= 0.92, 95%CI= 0.88 to 0.96) categories than others.

**Table 3**

*Binary Logistic Regression of Marriage Below 18 Among Ever-Married Women Aged (15-49 Years) in India, 2019-21*

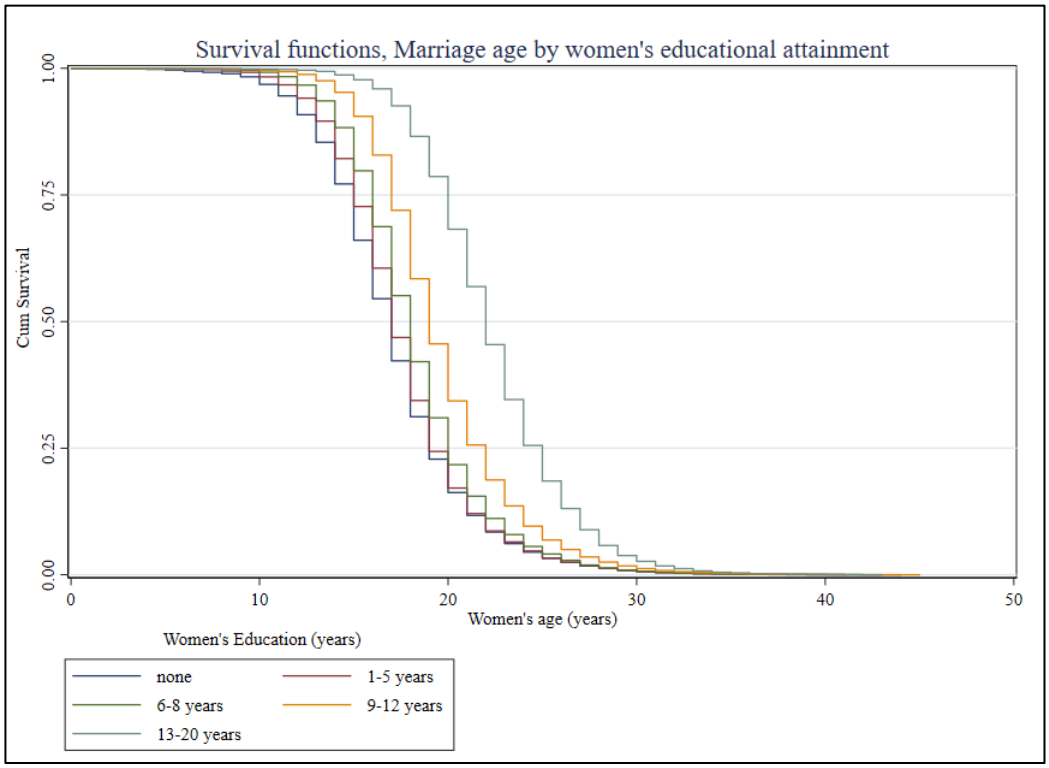
| Background Characteristics | Model 1 (*n=75,826*) Model fit *p*=0.001 | | Model 2 *(n=75,826)* Model fit *p*=0.001 | |
|---|---|---|---|---|
| | OR | CI (95%) | AOR | CI (95%) |
| Women's Education (y) | | | | |
| none ® | | | | |
| 1-5 | 0.88*** | [0.84,0.92] | 0.90*** | [0.86,0.94] |
| 6-8 | 0.64*** | [0.61,0.67] | 0.65*** | [0.62,0.68] |
| 9-12 | 0.31*** | [0.30,0.32] | 0.31*** | [0.29,0.32] |
| 13-20 | 0.06*** | [0.05,0.06] | 0.06*** | [0.05,0.07] |
| Women's Current Age (y) | | | | |
| 15-24 ® | | | | |
| 25-34 | | | 0.70*** | [0.66,0.73] |
| 35-49 | | | 0.72*** | [0.68,0.76] |
| Caste | | | | |
| SC | | | 0.96 | [0.91,1.01] |
| ST | | | 0.70*** | [0.66,0.74] |
| OBC | | | 0.92*** | [0.88,0.96] |
| Others ® | | | | |
| Religion | | | | |
| Hindu ® | | | 1.35*** | [1.29,1.41] |
| Others | | | | |
| Place of Residence | | | | |
| Urban ® | | | | |
| Rural | | | 1.03 | [0.96,1.05] |
| Region | | | | |
| North ® | | | | |
| Central | | | 1.52*** | [1.45,1.60] |
| East | | | 1.93*** | [1.82,2.04] |
| North-East | | | 1.28*** | [1.20,1.36] |
| West | | | 1.31*** | [1.23,1.40] |
| South | | | 1.52*** | [1.44,1.61] |
| Wealth Status | | | | |
| Poorest | | | 1.06 | [0.98,1.14] |
| Poor | | | 1.15*** | [1.08,1.23] |
| Middle | | | 1.14*** | [1.07,1.21] |
| Richer | | | 1.06 | [0.99,1.12] |
| Richest ® | | | | |
| Mass Media Exposure | | | | |
| Not exposed ® | | | | |
| Exposed | | | 0.93*** | [0.90,0.97] |
| Women's Occupation | | | | |
| Not working ® | | | | |
| Agriculture | | | 1.20*** | [1.15,1.25] |
| Other sectors | | | 1.15*** | [1.09,1.20] |
| Type of Marriage | | | | |

| Background Characteristics | Model 1 (*n=75,826*) Model fit *p*=0.001 | | Model 2 *(n=75,826)* Model fit *p*=0.001 | |
|---|---|---|---|---|
| | OR | CI (95%) | AOR | CI (95%) |
| Non-consanguineous ® | | | | |
| Consanguineous | | | 1.15*** | [1.09,1.20] |
| Decision Making Autonomy | | | | |
| High ® | | | | |
| Medium | | | 1.11*** | [1.08,1.15] |
| Low | | | 1.12*** | [1.06,1.19] |
| *Note: ®: Reference group; 95% confidence intervals in brackets * p<0.05, ** p<0.01, *** p<0.001* | | | | |

The women from a low economic background (OR=1.15, 95%CI= 1.08 to 1.23) had a higher probability of early marriage than those from rich households. Early marriage was higher among women not exposed to mass media than those exposed (OR 0.93, 95%CI = 0.90 to 0.97). In the case of marriage, where wives were previously related to their husbands or partners, they had a higher probability of getting married below 18 years of age than women who were not related to their husbands earlier.

**Figure 1**

*Kaplan-Meier Survival Curves of Women's Age at Marriage by Levels of Women's Education for 15-49 Years Ever-Married Women*



The survival curves (vertical lines) represent the probability of women delaying marriage age for all women in our sample. The curves are stratified by five (differently coloured) women's educational attainment levels. Deep blue denotes no education, purple 1–5 years of schooling, green 6–8 years, orange 9–10 years, and light blue 13-20 years of schooling.

### Kaplan-Meier Survival Analysis of All Ever-Married Women

The Kaplan-Meier survival curves demonstrate distinct differences across women's educational levels regarding the likelihood of postponing marriage age **(**Figure 1)**.** It was found that women with a certain level of education could postpone their marriage at later ages. These findings made it abundantly evident that education level positively affected postponing the marriageable age of women. The likelihood that women will survive marriage likewise improved with increased levels of education.

## Discussion

The study found that women with no and the lowest level of education are vulnerable to early marriage. Precisely, additional levels of education enable women to postpone their marriage age beyond the legal age. The results of our research are consistent with the findings of other previous studies in the developing world (Bongaarts et al., 2017; Pandey, 2017; Raj et al., 2014; Sabbah-Karkaby & Stier, 2017; Wodon et al., 2017). Nevertheless, a previous study showed that due to early marriage, women tend to reduce literacy and education attainment (Nguyen & Wodon, 2014). This implies that the causality effect between early age at marriage and educational attainment are both-sided; both influence each other per different sociocultural aspects. In a patrilineal society like India, girls have few educational opportunities, where disparities are deeply embedded in sociocultural conventions.

At the aggregate level, poverty was found to be a key driving force for child marriage, implying that, besides promoting women's education, eradicating poverty should be a top priority in combating the prevalence of early-age marriages among women. Our study found that women from poor economic backgrounds were more vulnerable to getting married earlier than those from richer households. This finding conforms to past studies (Jain et al., 2007; Kamal et al., 2015; Mathur et al., 2003; UNFPA, 2012). In India, girls are seen as a burden to their parents, and they think they have to pay a lesser amount of dowry if they wed their daughters early. Dowry is traditionally supposed to be paid by the daughter's family to the groom's family in exchange for agreeing to keep their daughters.

Furthermore, in patrilineal Indian society, girls' virginity has been greatly regarded (Amin & Bajracharya, 2011; Caldwell, 2005; Jensen & Thornton, 2003; Nour, 2009). This study also found that religion substantially influences women's marriage age. Women who practice Hinduism were much more vulnerable to marrying before 18, as marriage is recognised as a sacrament in Hindu tradition,

which also earns religious praise (Agarwala, 1957; Arnold et al., 1998). The findings of our study imply that women's autonomy plays an important role in selecting their age at marriage. Autonomy can be increased by promoting girls' education, changing social norms, and providing more economic opportunities for women, which is consistent with previous literature (Lee-Rife et al., 2012; Parsons et al., 2015).

There are several strengths and limitations of this study. In this study, we employed the most recent large-scale nationally representative data, allowing us to reflect on the current situation of early marriage across the country. The study identified the predictors of low age at marriage, especially the positive role of education, thus reemphasising the benefits of programs like universal free education to all. The results are useful for customised region/state-specific intervention to prevent early marriages. However, the cross-sectional nature of the dataset does not allow for any causal inference. Moreover, the role of early marriage in educational attainment has yet to be explored. However, these limitations will unlikely diminish the findings' reliability and usefulness.

## Conclusion

Early marriage possesses long-term negative consequences for both current and future generations. This study found that education continues to be a major factor in early marriage for women in India. Girls with no education or only an elementary education are more likely to marry at a young age. The results suggest the need for continued emphasis on girls' education, especially those from low socioeconomic backgrounds. The improved age at marriage of women will also help achieve Sustainable Development Goal (SDG) Target 5.3, which aims to "eliminate all harmful practices, such as child, early, and forced marriage, and female genital mutilation," to end child marriage by 2030.

## Conflicts of interest

The authors have no conflicts of interest.

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# Female Literacy, Internet Use, and Marriage in Predicting Total Fertility Rate: An Inter-State Analysis

**Narendra Pal Singh Chandel and Shalini Verma[1]**

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**Abstract**: This paper aims to analyse the total fertility rate of different states in India and to find the contributing role of Female literacy, internet use, and marriage in determining it. The major research questions are: What is the relationship between Female literacy, internet use, and marriage with the total fertility rate? What is their contribution to determining the total fertility rate? Data has been taken from the National Family Health Survey-5. Multiple regression analysis was performed to find the contributory role. Results show that the total fertility rate has a negative relationship with Female literacy and internet use and a positive relationship with Females' marriage (percentage of women aged 20-24 married before 18 years). Female literacy, internet use and marriage contribute 5.31, 17.90 and 4.84 per cent, respectively, in total fertility rate. In comparison, the total contribution of these three variables to the total fertility rate is 28 per cent.

**Keywords:** National Family Health Survey-5, female literacy, internet use, marriage, multiple regression

The total fertility rate (TFR) rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children per age-specific fertility rates of the specified year. It is expressed as live births per woman. (United Nations, 2019; The World Bank, 2022). TFR is an indicator of several socio-economic and demographic characteristics of a population.

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High TFR indicates that the population has a low income, low literacy, and low socio-economic status in general and specifically in the women category. A decrease in TFR indicates that the socio-economic characteristics of that population in general and women in specific are improving. Low TFR also indicates that the population is literate, marriages are done late, income is improving, and women are becoming more empowered.

A TFR of 2.1 is required to replace the population. When TFR goes below 2.1, that population cannot replace itself. Low TFR is now a new challenge in all developed and developing countries (Nargund, 2009; Eslami, 2016), but many developing countries are still facing the issue of high TFR. The TFR of less developed countries is three times higher than that of more developed countries (El-Ghannam, 2005). According to the data of World Population Review 2022, less developed countries like Niger (6.8), Mali (5.8), Chad (5.6), etc., have very high TFR, whereases developed countries like Hong Kong (1.1), Germany (1.5), Australia (1.7) having low TFR. Three demographic processes may change the size of an area's population: birth, death, and migration. The developed world is now facing the problem of a shrinking population caused by the lowest TFR (ranging from 1.1 to 1.3). The ageing population is a common problem in middle and high-income group countries. TFR can be decreased by improving the population's educational, economic, and health status, but increasing TFR is a much greater challenge than reducing it. Historically, governments have succeeded in slowing fertility declines through various interventions. However, more than a single policy intervention is required to reverse low fertility in all cases (Grant et al., 2004).

India has a diverse population living in different regions or states with different parameters like sex ratio, education, population density, marriage, age of marriage, internet use, literacy, awareness, etc. Due to these diversities, the difference in TFR is found among the states. Now, India has attained a TFR of 2.00, which is below the replacement level of the population. This indicates that India's population explosion is now checked. Now, India should not focus on reducing the fertility rate but on retaining it at its present level to maintain the young dependency ratio at its present levels. TFR is affected by many variables like education, health, income, marriage, awareness, use of contraceptives, women empowerment etc. (Jejeebhoy, 1995; Lutz, 2014; Colleran et al., 2014; Wang & Sun, 2016). The present study is an effort to find the relationship of TFR with Female literacy, internet use, and marriage and the contribution of these factors in determining TFR.

## Research Questions

After reviewing international and national research related to TFR, the present research has been taken up to answer the following research questions in the Indian context:

1. What are the regional disparities in TFR in India?

2. What is the relationship of TFR with Female literacy, internet use, and marriage?
3. How do Female literacy, internet use, and marriage determine the TFR?

### Objectives of the Study

1. To find the regional disparities in TFR in India.
2. To find the relationship of TFR with Female literacy, internet use, and marriage.
3. To find the contributory role of Female literacy, internet use, and marriage in determining the TFR.

### Hypotheses

$H_{\alpha 1}$ There exist regional disparities in TFR.

$H_{\alpha 2}$ TFR, Female literacy, internet use, and marriage are significantly correlated.

$H_{\alpha 3}$ Female Literacy, Internet Use, and Marriage significantly contribute to TFR.

## Materials and Methods

### Data Collection

Data for the present research has been taken from the National Family Health Survey (NFHS-5), 2019-21 (Phase 1 & Phase 2).

### Size of the Sample

All 28 Indian States and 8 Union Territories have been selected as the sample for the analysis.

### Variables of the Study

#### *Independent Variables*

To find the contributory role, three independent variables, i.e., Percentage of Women aged 15-49 years who are literate* (WL), Percentage of Women aged 15-49 years who have ever used the internet (WI), Percentage of Women aged 20-24 years married before age 18 years (WM).

*Here, the word literate refers to Women who completed standard nine or higher and Women who can read a whole or part of a sentence (NFHS, 2021).

In this paper, the terms Females and Women have been used interchangeably.

#### *Dependent Variable*

Total Fertility Rate (TFR).

### Statistical Techniques Used

Correlation and multiple regression have been used to analyse the data.

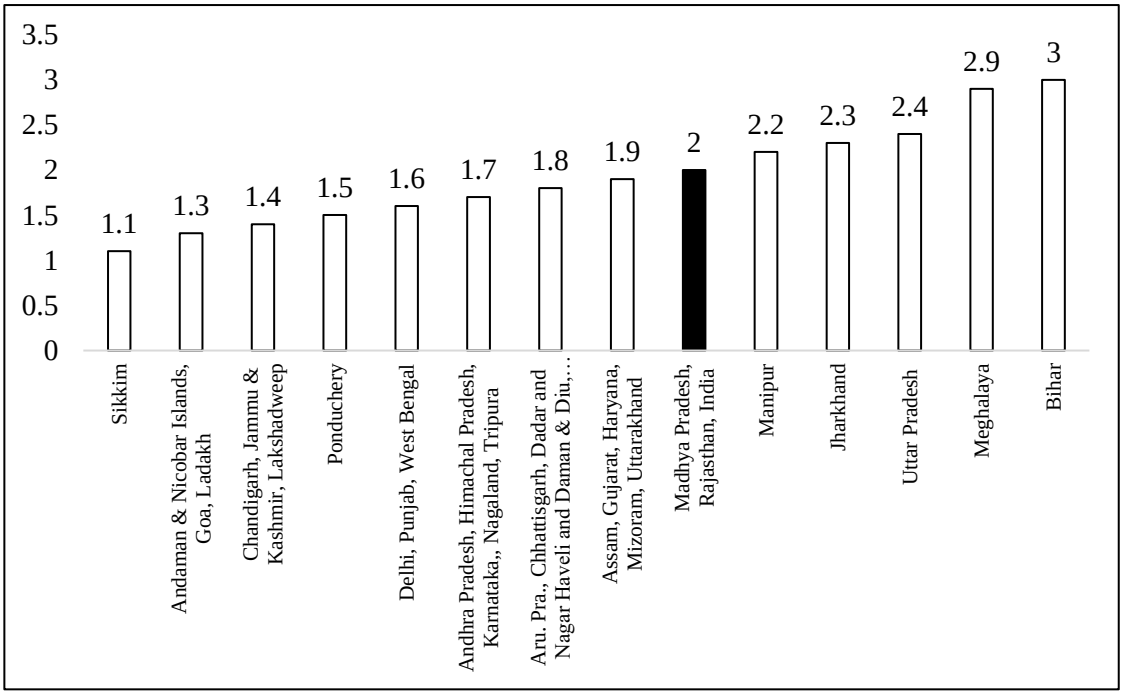
## Analysis and Interpretation of Data

### Regional Disparities in TFR

India has multiple languages, cultures, climates, lands, and diversities of educational, social, and economic development. All these diversities affect TFR. This can be observed from the data depicted in Figure 1 and Table 1.

**Figure 1**

*Graph Depicting TFR of Indian States and Union Territories (UTs)*




From Table 1, it is clear that Bihar has the highest TFR, i.e., 3, whereas Sikkim is the state having the lowest TFR, i.e., 1.1. Out of 36 states and UTs, a total of 31 States or UTs have TFR lesser than the replacement rate, whereas 5 States, namely Manipur, Jharkhand, Uttar Pradesh, Meghalaya, and Bihar, have TFR above the replacement rate. The above data reveals that in Lowest Low or nearby, the TFR category is highly dominated by smaller states and Union Territories like Sikkim, Andaman & Nicobar, Goa, Ladakh, Chandigarh, Jammu & Kashmir, Lakshadweep, and Puducherry. States which are low on economic and educational development indicators have higher replacement rates (2.1) of TFR, like Manipur, Jharkhand, Uttar Pradesh, Meghalaya, and Bihar. The above discussion reveals regional disparities in TFR among various states; therefore, alternative hypothesis Ha1 that *'there exist regional disparities in TFR'* is accepted.

**Table 1**

*TFR in India, States and Union Territories*

| TFR Level | TFR | States & Union Territories, India |
|---|---|---|
| Lowest Low TFR | 1.1 | Sikkim |
| | 1.3 | Andaman & Nicobar Islands, Goa, Ladakh |
| Lower Than Replacement Rate (1.4 to below 2.1) | 1.4 | Chandigarh, Jammu & Kashmir, Lakshadweep |
| | 1.5 | Pondicherry |
| | 1.6 | Delhi, Punjab, West Bengal |
| | 1.7 | Andhra Pradesh, Himachal Pradesh, Karnataka, Maharashtra, Nagaland, Tripura |
| | 1.8 | Arunachal Pradesh, Chhattisgarh, Dadar and Nagar Haveli and Daman & Diu, Kerala, Odisha, Tamil Nadu, Telangana |
| | 1.9 | Assam, Gujarat, Haryana, Mizoram, Uttarakhand |
| | 2 | Madhya Pradesh, Rajasthan, **India** |
| Higher than Replacement Rate (Above 2.1) | 2.2 | Manipur |
| | 2.3 | Jharkhand |
| | 2.4 | Uttar Pradesh |
| | 2.9 | Meghalaya |
| | 3 | Bihar |
| Source: National Family Health Survey (NFHS-5), 2019-21 | | |

## Relationship of TFR with Dependent Variables

Literacy, Internet use, and marriage are closely related to TFR. Literacy and internet use increase awareness, hence helping to reduce the fertility rate. Late marriage reduces the span available for reproduction, reducing the TFR. This can be observed from the correlation values in Table 2 and Figure 2.

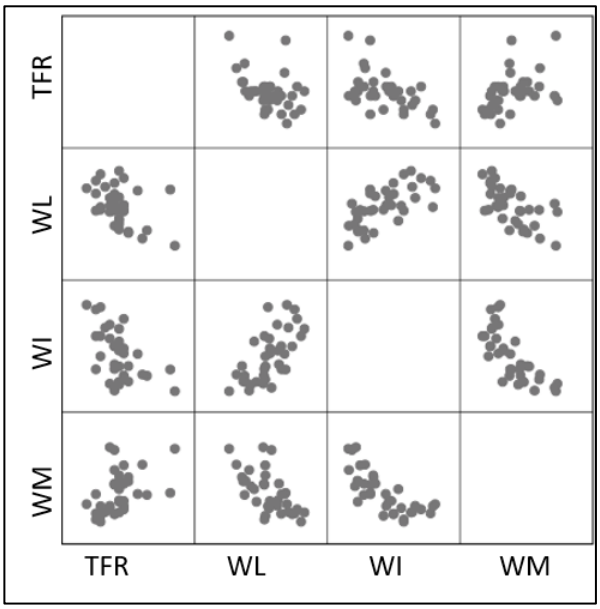
**Table 2**

*Correlation Matrix of TFR with Women Predictive Variables*

| | TFR | WL | WI | WM |
|---|---|---|---|---|
| TFR | 1.000 | -0.425 | -0.513 | 0.448 |
| WL | -0.425 | 1.000 | 0.668 | -0.625 |
| WI | -0.513 | 0.668 | 1.000 | -0.751 |
| WM | 0.448 | -0.625 | -0.751 | 1.000 |

**Figure 2**

*Relationship of TFR with Women Predictive Variables*




The correlation matrices presented in Table 2 reveal that TFR is negatively correlated with literacy (r = -0.425) and internet use (r = -0.513). As the literacy rate and internet use among Females increase, the TFR starts decreasing, whereas TFR and the percentage of Females aged 25-29 married before 18 years have a positive relationship (r = 0.448). It happens because marriage before the age of 18 increases the total span available for reproduction to a couple. A moderate positive correlation is found between literacy and internet use (r = 0.668), as literacy is a prerequisite for internet use. A negative correlation is found between the percentage of Females married before 18, literacy (r = -0.625), and internet use (r = -0.751). It shows that those who are literate and internet users get married late. The correlation values are either moderate or high. It shows that TFR values in India declined with the increment in literacy rate, high internet use, and a decline in the percentage of females getting married before 18. All the correlation values are significant at 0.001 level and df 34; therefore, alternative hypothesis $H_{\alpha 2}$ that '*TFR, Female Literacy, Internet Use, and Marriage are significantly correlated*' is accepted.

## To Find the Contribution of Females Literacy, Internet Use, and Marriage in Determining the TFR

Multiple linear regression analysis was carried out to predict the contribution of Female literacy, internet use, and marriage to the prediction of TFR. The purpose of applying multiple regression analysis is to test the following hypothesis:

*$H_{a3}$:* Females *literacy, internet use, and marriage significantly contribute to TFR.*

Before the analysis, the prerequisites of applying multiple regression have been checked. It was found that the dependent variable, i.e., TFR, and all three independent variables, i.e., FL, WI, and WM, are on a continuous scale. The independence of residuals was checked using Durbin-Watson statistics. The value of Durbin-Watson statistics is 1.594, which is normal because it comes under the range of 1.5 to 2.5 (Field, 2009). Hence, no autocorrelation has existed. The correlation values between a dependent variable and the independent variables in the model indicate that all model variables have the linearity of correlation. This can easily be seen by the correlation matrix table, i.e., Table 2 and Figure 2. Data from the model shows homoscedasticity; this can be seen in Figure 3. In Figure 3, the dots are evenly distributed, which reveals that data for this regression model shows homoscedasticity. Figure 4 shows the Normal P-P Plot of regression standardised residuals; here, dots are approximately aligned with the line, which shows that residuals (errors) are normally distributed. To check another assumption, i.e., absences of multicollinearity, VIF values and Tolerance values are used. Table 5 shows that tolerance values are greater than 0.2 for each variable, and VIF values are less than 3; hence, data for this regression model did not show multicollinearity.

**Figure 3**

*Scatterplot to Check Homoscedasticity of Data*

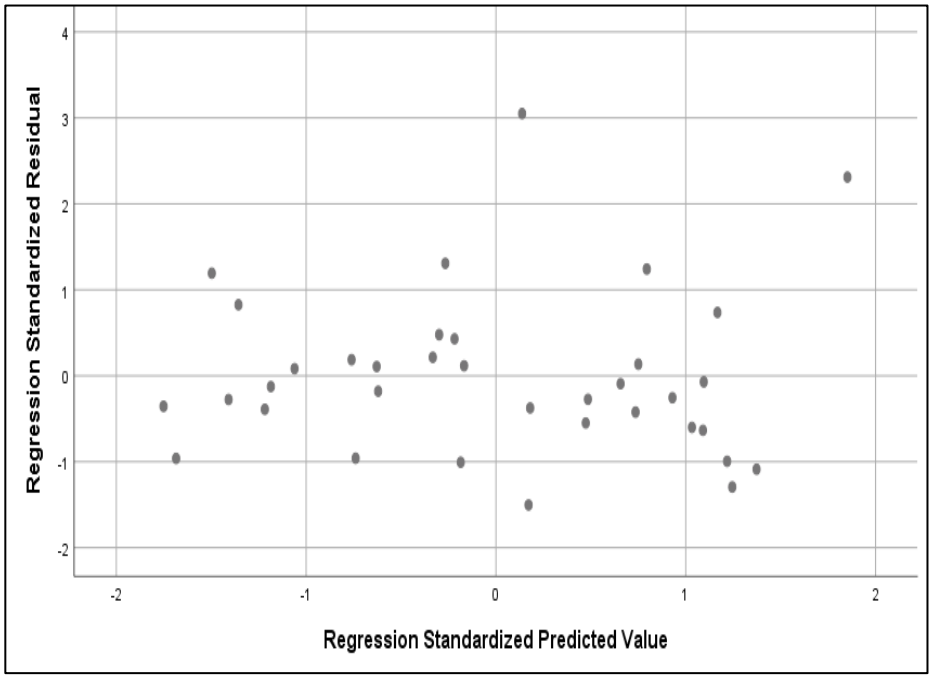
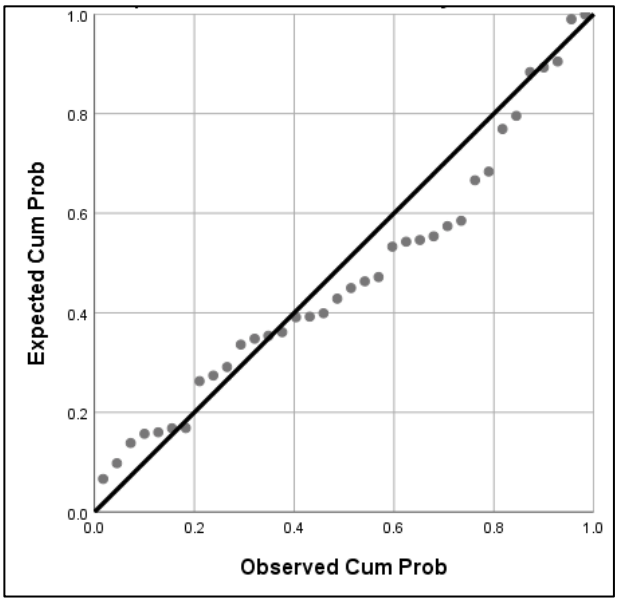


**Figure 4**

*Normal P-P Plot to Check Normality of Data*




From the above discussion, the model has fulfilled all the prerequisites and assumptions to apply multiple regression analysis. Following is the description of the multiple regression analysis results.

**Table 3**

*Summary of Multiple Regression Analysis*

| R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|
| 0.530[a] | 0.280 | 0.213 | 0.35291 |
| a. Predictors: Constant, WM, WI, and WL<br>b. Dependent Variable: TFR | | | |

It is evident from the Multiple Linear Regression Table 3 that the value of the *Multiple Correlation Coefficient*, R, is 0.53. It indicates a good level of prediction. The Coefficient of Determination, R square ($R^2$), obtained from Multiple Regression Analysis is 0.28. From this value of $R^2$, it can be concluded that there is a variation of 28% in the TFR due to the change in WL, WI, and WM Women predicting parameters, i.e., Literacy, Internet use, and Marriage, determine 28% of the criterion variable, i.e., TFR.

**Table 4**

*ANOVA for Multiple Regression*

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 1.553 | 3 | 0.518 | 4.158 | 0.014[b] |
| Residual | 3.985 | 32 | 0.125 | | |
| Total | 5.539 | 35 | | | |
| a. Dependent Variable: TFR | | | | | |
| b. Predictors: (Constant), WM, WI, and WL | | | | | |

The *F*-ratio in multiple regression tests, whether the overall regression model is a good fit for the data. The table shows that the independent variables statistically significantly predict the dependent variable, $F(3,32) = 4.158$, $p < 0.05$. Here, the F-ratio is significant at a 0.05 level of significance. This means that the regression model fits the data well or that a linear relationship exists between the predictive variables at a 0.05 significance level.

**Table 5**

*Coefficients for Multiple Regression*

| | Unstandardised Coefficients | | Standardised Coefficients | Correlations | Collinearity Statistics | | Contributory percentage | Percentage of Contribution |
|---|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | Zero-order | Tolerance | VIF | Beta * r | |
| (Constant) | 2.483 | 0.685 | | | | | | |
| WL | -0.005 | 0.008 | -0.125 | -0.425 | 0.519 | 1.926 | 0.0531 | 5.31% |
| WI | -0.008 | 0.006 | -0.349 | -0.513 | 0.372 | 2.690 | 0.1790 | 17.90% |
| WM | 0.004 | 0.008 | 0.108 | 0.448 | 0.409 | 2.446 | 0.0483 | 4.84% |
| a. Dependent Variable: Total Fertility Rate | | | | | | | | |

From the values given in Table 5, it is revealed that the values of unstandardised coefficients corresponding to each predictive variable are used to determine the relative change in TFR by unit change in predictive variables. From this, the general formula to predict TFR can be written as follows:

**TFR = 2.483 – 0.005*WL – 0.008*WI + 0.004*WM**

Where TFR=Total Fertility Rate, WL is the percentage of women aged 15-49 years who are literate, WI is the percentage of women aged 15-49 years who have ever used the internet, and WM is the percentage of Women aged 20-24 years married before age 18 years.

Unstandardised coefficients indicate how much the TFR varies with an independent variable when all other independent variables are constant. Here, the unstandardised coefficient for WL is equal to -0.005. This means that for each percentage increment in Female literacy, there is a decrease in TFR of 0.005. The unstandardised coefficient for WI is equal to -0.008. This means that for each percentage increment in Female internet use, there is a decrease in TFR of -0.008. Similarly, the unstandardised coefficient for WM is equal to 0.004. This means that for each percentage increment in Female marriage before age 18, there is an increase in TFR of 0.004.

Multiple Regression Analysis also produced individual contributions of predictive variables. The relative contribution of each Female predictive variable in the prediction of TFR is depicted in Table 8. The values obtained by multiplying β (standardised coefficient) and r (correlation coefficient) show the relative contribution of each predicting parameter. For Female literacy, the value is 0.0531, which means Female literacy contributes 5.31 per cent to TFR. Similarly, there is a 17.90 per cent contribution of Female internet use in TFR and a 4.84 per cent contribution of Female marriage in TFR. In contrast, the total contribution of these three variables in TFR is 28%.

From the results obtained, in this model, Female internet use was the most important contributor to predicting TFR. In contrast, the contribution of Female literacy and marriage was found to be comparatively less in predicting TFR.

## Findings, Discussion, and Conclusion

It is observed from the above analysis that, at present, a relationship exists between TFR and Female literacy, internet use, and marriage in India. These factors also contribute to determining TFR. It can be said that efforts made by the government to bring women into the mainstream of society are slowly paying off as the determining factors of TFR are high (WL & WI) and low (WM) in the States where the TFR is low, and vice versa. A state like Bihar has TFR 3 and shows 57.8 per cent of Female literacy, 20.6 per cent of Females are using the internet, and 40.8 per cent of Females get married before age 18. This data is much diverted compared to the state Sikkim, which shows 88.9 per cent women literacy, 76.7 per cent of women are using the internet, and only 10.8 per cent of females get married before age 18. This data also supports findings showing that Female literacy, marriage, and internet use contribute to determining TFR. It became increasingly clear that once fertility reaches very low levels, there is greater difficulty in crafting effective policies to reverse the fertility decline (Silva, 2008). Policy reform is needed to retain India's TFR at its current level. The literature suggests that this is less attributable to a single policy mechanism than its ability to create an environment encouraging childbearing. This environment is created by a combination of policies that jointly serve this aim (Grant et al., 2004). Hence, with reforming policies of the states

having high TFR, other stakeholders concerned with this matter should continue to encourage women to get educated and make them aware of the consequences of getting marked early and having more children.

Meanwhile, some incentives should be provided to literate women and their families so that while pursuing their careers and studies, they may easily give birth and care for their children. This may include providing maternity leave for two or three times, childcare leaves to both parents, flexibility in working hours, flexibility for working from home, and opening and maintaining childcare centres and creches near the workplace or childcare facilities within the workplace. These are some suggestions that can be helpful to maintain the TFR without compromising women's education and careers. To provide such incentives, there is a need to reform policies at the national and state levels and at the local and organisational levels, by which flexibility will be provided to the Female workforce in the government and private sectors.

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# Population Distribution of Agartala City and its Significance on Urban Planning and Development

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**Abstract:** Population distribution in an urban area is a critical decision-making factor for urban governance. Agartala, the capital city of Tripura, is the second-largest populated and fastest-growing city in Northeast India. This city is uniquely located in the extreme western part of the State of Tripura, extending between 23°45′N to 23°55′N latitudes and 91°15′E to 91°20′E longitudes, covering an area of 76.150 km² sharing an international boundary with Bangladesh. This paper analyses the distribution of the city's population along with its statistical measures and spatial structure based on the population data in 2018 of Agartala Municipal Corporation (AMC). Further, this paper analyses the causality of the population distribution of Agartala City. It has been found that road networks, marketplaces and educational institutes significantly impact the city's population distribution. It helps in the micro-level resource distribution and unit for sustainable development. It relates to the micro-level resource allocation and urban planning decision support system.

***Keywords***: spatial distribution, alternative synthetic indicator, population density, regional classification, border city

In urban planning and management, the nature of a city's population distribution is a key area of concern (Du et al., 2006). The urban area's distribution and population size dynamics are crucial to managing growth and mitigating the negative impacts (Decker et al., 2007). Population distribution measurement mainly focuses on spatial and categorical (Duncan, 1957). The spatial characteristics of

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population distribution are considered in urban planning and management (Song & Prishchepov, 2017). The development of highly concentrated urban structures suffers from heterogeneous populations (Tsuboi et al., 2016). The heterogeneous population distribution is levelled with multifactorial issues like demographic attributes, socio-economic conditions, transport infrastructure, physical infrastructure, cultural landscape, land use pattern and development across space and time (Chi & Ventura, 2011). Spatial heterogeneity of population distribution has numerous impacts on urban sustainability (Zhou et al., 2016). About 50 per cent of the world's population is concentrated in six countries: China, India, the United States of America (USA), Indonesia, Brazil and Pakistan (Hackett, 2018). With a 73,899,804 population, China is the world's largest populated country (The Economic Times, 2020). According to the Census of India, 2011, India became the second-largest country after China regarding population size, with a population of 1.21 billion (Shaban et al., 2020). India is the fifth largest country in terms of urban inhabitants after the USA, Russia, China, and Japan (Eberstadt, 2010). Census of India, 2011 depicts that during the decade 2001-11, India's urban population growth was slightly higher than that of the rural population (Aijaz, 2021). Agarwal (2020) reported that 70 per cent growth had been found in urban areas. In India, there are more than 4000 cities and towns. A city's population growth depends on time and space (Tumbe, 2020). Haque and Patel (2017) show that those metro cities, especially the state capitals at the riverbank with better quality public services, grow faster than other cities.

Northeast India is uniquely located in the eastern fringe of the country with its dissentient physiographic features, dissonant social structure, and divergent cultural entity (Singh, 2006). The Northeastern region comprises eight distinct and diverse states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim (Roy & Mitra, 2016). This region was largely rural since pre-independence, but urbanisation has been faster in the last quarter of the 20$^{th}$ century (Khawas, 2005). The urbanisation process and the increasing urban population are not equally distributed in all Northeastern states (Tumbe, 2017). Sahay et al. (2015) stated that the Northeastern region is home to 45 million people or about 3.8 per cent of the country's total population, of which 68 per cent live in Assam alone. Guwahati Municipal Corporation (GMC) was established in 1974 with 34 wards and has risen to 60 (Desai & Mahadevia, 2013). The population of Guwahati Municipal Corporation increased from nearly three hundred thousand to 1.3 million in 2011 (Sahay et al., 2015). Agartala is the second most populated and one of the country's fastest-growing cities (Santra et al., 2018). Debbarma et al. (2018) show that the population of Agartala City is not equally distributed among 35 wards based on the data from the Census of India, 2011. As per notification (No.F.II-24/GL/OATH/AMC/2012/Vo-II/26335-427) of the Municipal Commissioner on 29$^{th}$ December 2015, Agartala Municipal Corporation (AMC) had increased to 49 wards from 35 wards, and population and area increased significantly. With the increased area and population, Agartala City evolved with a new distributional pattern of

population. The study's main objective is to determine the characteristics of population distribution and the causality of heterogeneous distribution.

**Study Area**

Agartala, the capital city of Tripura, is situated between 23° 45ˈto 23° 55ˈ N latitudes and 91°15ˈ to 91°20ˈ E longitudes (Fig. 1). The city is located in the flood plain of the River Haora and Kata Khal. The physiographic structure of Agartala City is saucer-shaped and characterised by Tilla (relatively high land) and Lunga (low land) topography (Sen et al., 2015). The Agartala Municipal Council was established long before, in 1874. In 2014, it was upgraded into Agartala Municipal Corporation (AMC), representing the local urban governance of Agartala City. Since its statehood, the city has become the centre of the state's administrative, political, cultural, and commercial activities. The city has become an essential border trading centre with international linkage with Bangladesh. The National Highway-8 passes through the city (Fig. 1). Maharaja Bir Bikram Airport [23°53'33.96" N and 91°14'37.81" E] is located about11.75 km northwest of the Central Business District (CBD) of Agartala City. The city is divided into four planning zones (North et al.) and shares the international border with Bangladesh on the western side. Jirania Rural Development (RD) Block, Mohanpur R.D. Block and Dukli R.D. Block are situated east, north, and south of the city. The total area of AMC is almost 76.150, with 5,26,292 people (AMC, 2018).

## Materials and Methods

The study is based on secondary data collected from the Agartala Municipal Corporation (AMC) office in 2020. Very recently, the AMC area was extended in 2016. Also, AMC conducted the last population survey of Agartala City in 2018. Thus, we have considered the latest ward-wise population data (2018) and ward-wise area (2016) for the study instead of the 2011 Census of India.

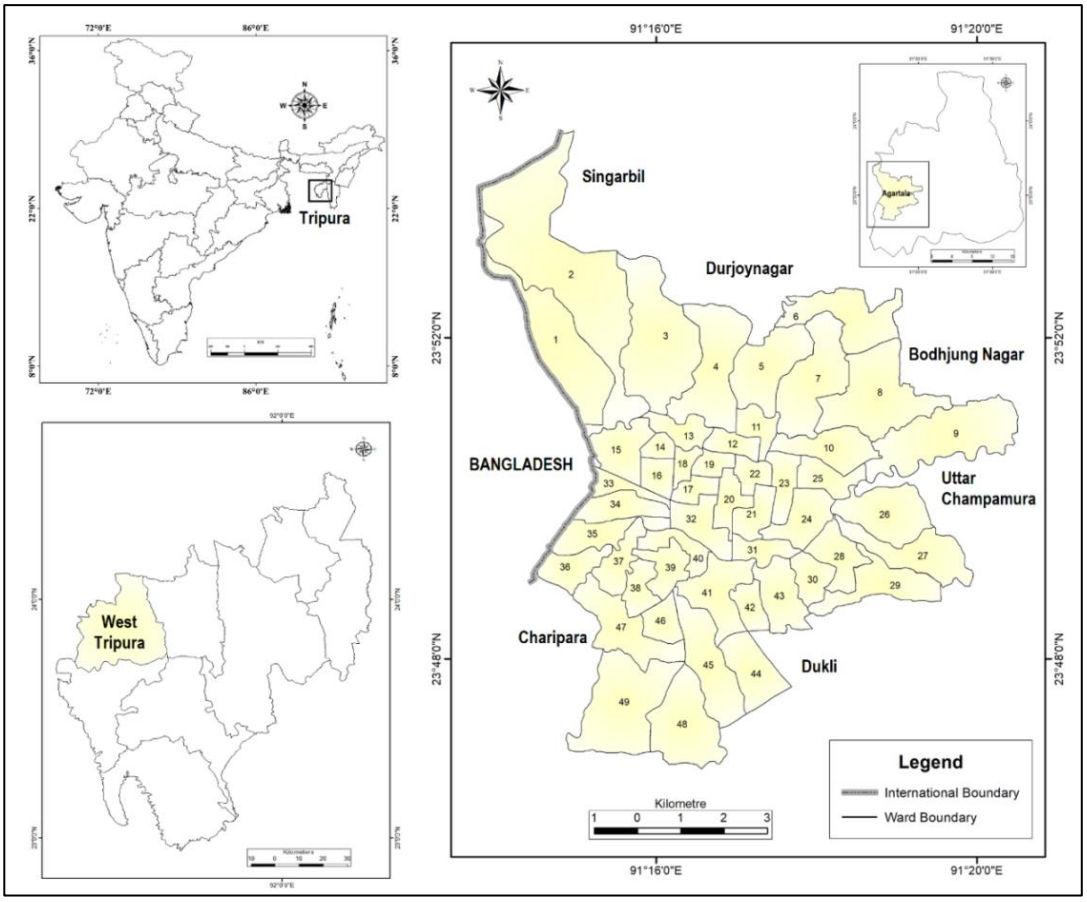
We have considered each ward's population, area, and population density as the study variables. At first, the normality of these variables' data observations is analysed through the Shapiro–Wilk test (Mishra et al., 2019). The Q-Q plot is a graphical tool for assessing the goodness-of-fit of observed data to a theoretical normal distribution (Velez & Correa, 2015). A graphical technique like the Quantile-Quantile (Q-Q) plot has also been applied for normality assumption. The degree of asymmetry (third central moment) and peakedness of datasets are carried out with skewness and kurtosis, respectively, using SPSS v26.

The non-normality of the data sets is observed through Shapiro-Wilk's test. Therefore, the existing Synthetic Indicator (Jaroca & Glinska, 2017) may need to be revised to classify the heterogeneity of data sets. A new Synthetic Indicator noted as an Alternative Synthetic Indicator (ASI) has been suggested here for those non-normal data sets, where the indicator is structured as the linear order of the median

(as a measure of central tendency) and mean deviation about median (as a measure of dispersion).

**Figure 1**

*Location Map of the Study Area*




Source: Prepared by the authors, 2021; Extracted from AMC Ward Boundary Map, 2016

Based on standardised data, the city has been classified into different classes. The Mean Centre of Population has been calculated and mapped using ArcGIS v10.7.1. The zonal distribution of the population has been measured using the Inverse Distance Weighted (IDW) method of interpolation (Wang et al., 2019).

Spatial distribution of different infrastructural facilities, i.e., road networks, marketplaces, and educational institutes, are mapped, and Spearman's rank correlation tests have been performed between population density and each of the above-mentioned infrastructural facilities to understand the role of infrastructural facilities on the distribution of population distribution in a city.

## Results and Findings

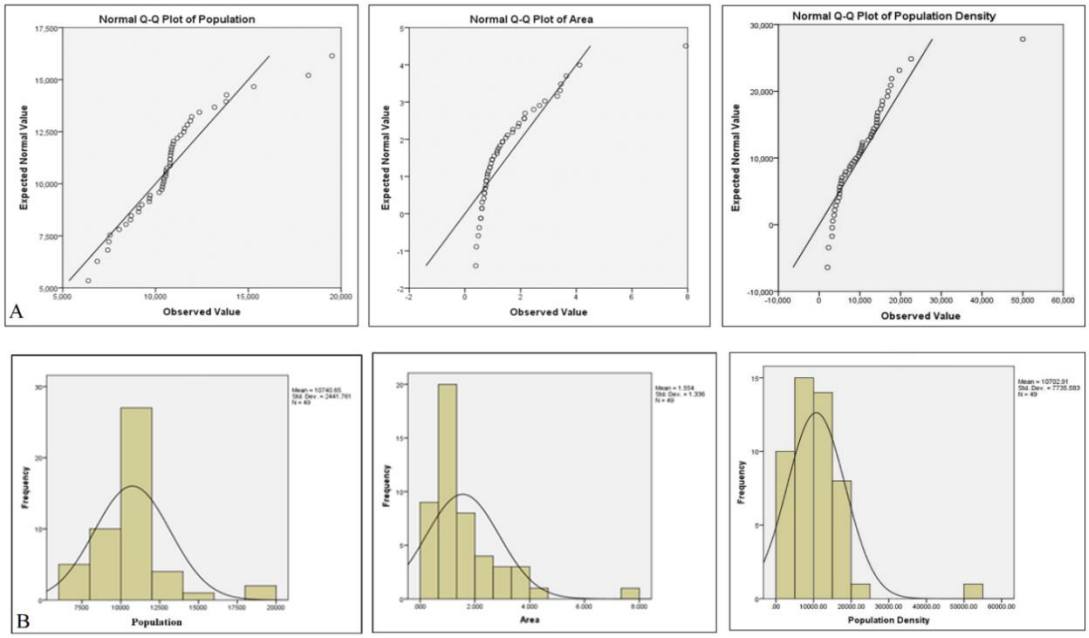
Following Shapiro-Wilk's normality test, it has been found that both the data of ward-wise population distribution (1.354) and area (1.239) are non-normal at a 5 per cent level of significance.

Shapiro-Wilk's test forward-wise population distribution shows the parameter is 0.878498, and the corresponding p-value is 0.00012 (<0.05). Since the p-value is <0.05, the data is assumed to be non-normally distributed. The area of wards is also found to be non-normally distributed. Shapiro-Wilk's parameter value of the area of wards is 0.739631, and the p-value is 0.00000005719 (<0.05). Similarly, ward-wise population density corresponding to the Shapiro-Wilk test parameter value is reported as 0.77716, and the p-value is 0.000033503 (<0.05).

The Q-Q plot also nullifies the normality assumption (Fig. 2 A). Skewness (1.43) of ward-wise population distribution shows the degree of asymmetry with right or positively skewed (long right tale), and kurtosis (Leptokurtic: 3.98) is positive and balancing to shift toward the tails. The distribution of ward area was also observed with positively skewed (2.67) and leptokurtic distribution (9.93), showing long heavy tails where the peak is low but a high peak with some values far from the mean (Fig. 2B). Similarly, skewness and kurtosis of population density are 2.808658 [(Positively skewed) and 13.050506 (Leptokurtic), respectively.

**Figure 2**

*(A) Q-Q Plot for Normality Assumption (B) Skewness Plot for the Degree of Asymmetry of Population, Area and Population Density of Agartala City*




Source: Prepared by the authors, 2021 using SPSS V26

The key factors are to classify the ward-wise heterogeneity of distribution of ward-wise population and ward-wise area in AMC. It is also considered that each ward's population density is a variable for classification through existing synthetic indicators and suggests alternative synthetic indicators. Population density has been efficiently measured to represent population distribution per unit area (population/km$^2$). Synthetic Indicator (SI) and Alternative Synthetic Indicator (ASI) classify population density.

According to SI, three (6.12%) wards, i.e.,14, 17 and 31 of Agartala City, have been categorised as very high-density population zones (Table 1). These three wards are scattered and distributed in the central part of Agartala City (Fig 3A). Further, it is observed that 17 (34.70%) wards of Agartala City have been categorised in a high population density zone. The wards are 12, 46, 33, 42, 18, 19, 11, 38, 16, 13, 21, 22, 40, 25, 23, 20 and 39 where population density varies between 10,703 persons per km$^2$ to18,438 persons per km$^2$ (Table 1). A highly dense population zone covers almost all the areas of the central part of the city (Fig. 3A). Ward No. 33, characterised by a very high population density, is stretched from the city's centre towards the border of Bangladesh on the west. Low-density population zone has been found in 27 (55.10%) wards of Agartala City which are 30, 36, 10, 32, 26, 37, 28, 24, 34, 43, 35, 41, 29, 15, 47, 6, 5, 27, 48, 45, 44, 7, 9, 4, 3, 8 and 49 (Table 1). The low-density population zone is normally located in the peripheral part of the Central Business District (CBD) as well as the marginal wards of the city (Fig. 3A). On the other hand, a Very low-density population zone is found in only ward number Two (2). Another one (1) is located along the city's northwest border (Table 1) because these are newly added. These areas were under gram panchayat, where most people were engaged in agricultural activities. Due to recent transformation, the need for other infrastructural facilities like connectivity, markets, and schools affects the population concentration.

**Table 1**

*Classification of Population Density of Agartala City by Synthetic Indicator (SI)*

| | Method of calculating class | Class range | Characteristic of class | Number of the ward | % of ward |
|---|---|---|---|---|---|
| I | $z_i \geq \bar{z} + \sigma_i$ | $z_i \geq 18438$ | Very high density | 14, 17 and 31 | 6.12 |
| II | $\bar{z} \leq z_i \leq \bar{z} + \sigma_i$ | $10703 \leq z_i \leq 18438$ | High density | 12, 46, 33, 42, 18, 19, 11, 38, 16, 13, 21, 22, 40, 25, 23, 20 and 39 | 34.70 |
| III | $\bar{z} - \sigma_i \leq z_i \leq \bar{z}$ | $2967 \leq z_i \leq 10703$ | Low density | 30,36, 10, 32, 26, 37, 28, 24, 34, 43, 35, 41, 29, 15, 47, 6, 5, 27, 48, 45, 44, 7, 9, 4, 3, 8 and 49 | 55.10 |
| IV | $z_i \leq \bar{z} - \sigma_i$ | $z_i \leq 2967$ | Very low density | 2 and 1 | 4.08 |
| Source: Computed by the Authors, 2021 | | | | | |

**Table 2**

*Classification of Population Density of Agartala City by Alternative Synthetic Indicator (ASI)*

| Class | Method of calculating class | Class range | Characteristic of class | Number of the ward | % of ward |
|---|---|---|---|---|---|
| I | $y_i \geq y + MD_{\bar{y}}$ | $y_i \geq 15166$ | Very high density | 14, 17, 31, 12, 46, 33, 42, 18, 19 and 11 | 20.41 |
| II | $y \leq y_i \leq y + MD_{\bar{y}}$ | $9905 \leq y_i \leq 15166$ | High density | 38, 16, 13, 21, 22, 40, 25, 23, 20, 39, 30, 36, 10 and 32 | 28.57 |
| III | $y - MD_{\bar{y}} \leq y_i \leq y$ | $4644 \leq y_i \leq 9905$ | Low density | 26, 37, 28, 24, 34, 43, 35, 41, 29, 15, 47, 6, 5, 27, 48, and 45 | 38.78 |
| IV | $y_i \leq y - MD_{\bar{y}}$ | $y_i \leq 4644$ | Very low density | 44, 7, 9, 4, 3, 8, 49, 2 and 1 | 18.37 |
| Source: Computed by the authors, 2021 | | | | | |

On the contrary, 10 (20.41%) wards, i.e., 14, 17, 31, 12, 46, 33, 42, 18, 19 and 11 of Agartala City have very high population density, among which six (60%) are located in the central part of Agartala City (Fig. 3B). Ward No. 33 is characterised by a high population density stretched from the centre of the city towards the border of Bangladesh on the west. Further, 14 (28.57%) wards of AMC have high population density, i.e. 38, 16, 13, 21, 22, 40, 25, 23, 20, 39, 30, 36, 10 and 32. Those wards are located adjacent to very highly dense populated wards (Fig. 3B). About 16 (38.78%) low, densely populated wards are found at the periphery of wards with high population density (Fig. 3B). Those wards are 26, 37, 28, 24, 34, 43, 35, 41, 29, 15, 47, 6, 5, 27, 48 and 45. Considering the zonal distribution of the city, 2 (13.33%), 5 (33.33%), 4 (26.66%) and 4 (26.66%) wards characterised by low-population density are found in the north, south, the east and western part, respectively of Agartala City.

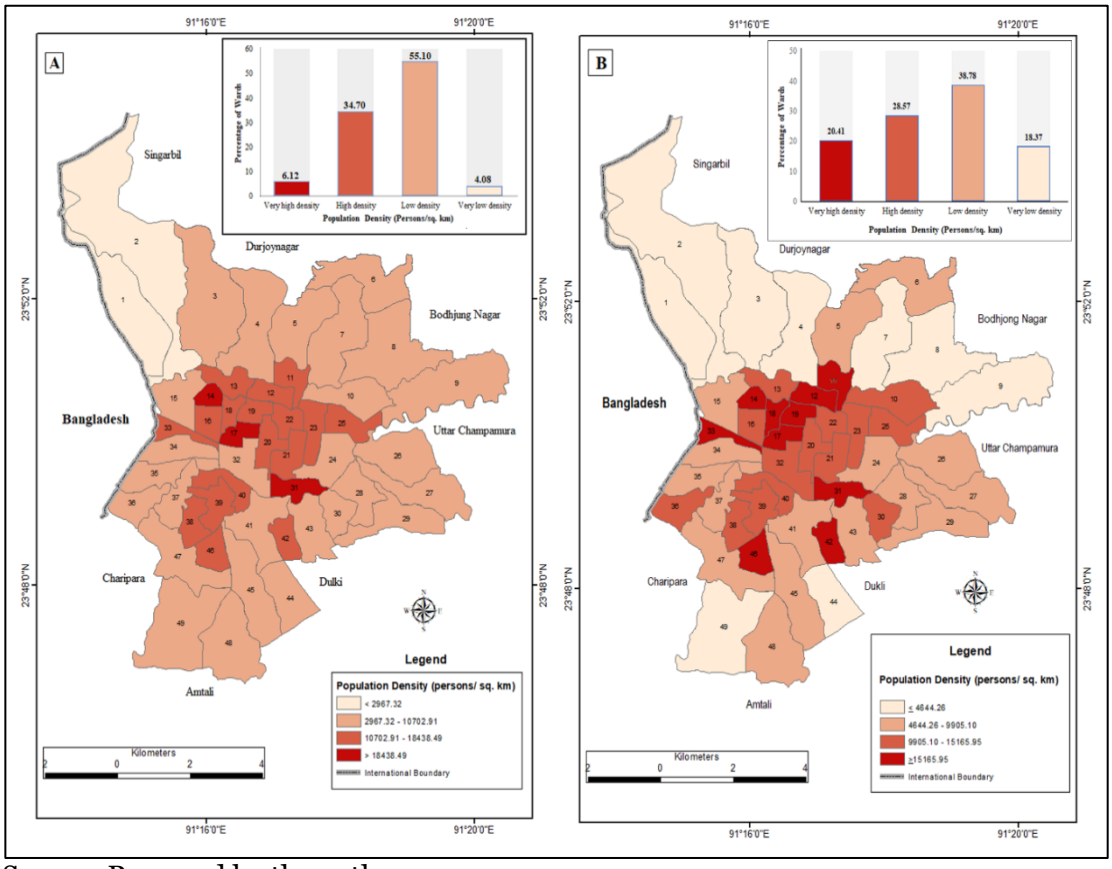
Further, Ward numbers 44, 7, 9, 4, 3, 8, 49, 2 and 1 of Agartala City have been observed to have a very low population density (Table 2). Among them, 7 (77.78%) wards, i.e., 1, 2, 3, 4, 7, 8 and 9, are located at the margin of Agartala City, especially in the northern part and the rest 2 (23.33%) wards, namely 44 and 49 are located in the southern margin of the city.

There is a significant range of disparities in classifying wards (Figure 3) through synthetic and alternative synthetic indicators. The weightage (percentage of ward distribution) range of classification is 51.02 (55.10-4.08) and 12.24 (30.61-18.37) through SI and ASI, respectively. The variance weightage is estimated and identified as $V_{SI}$ and $V_{ASI}$ for SI and ASI. Here $V_{SI}$= 598.0669 and $V_{ASI}$ =42.6564. The gain in efficiency of ASI over SI is measured as $\frac{(V_{SI}-V_{ASI})}{V_{ASI}}$= 13.0205. It shows that our

suggested ASI is more efficient than the existing SI, and classifications of wards of AMC, as reported in Table 2, are more appropriate.

**Figure 3**

*Ward-wise Population Density of Agartala City Through Synthetic Indicator (A) and Alternative Synthetic Indicator (B)*

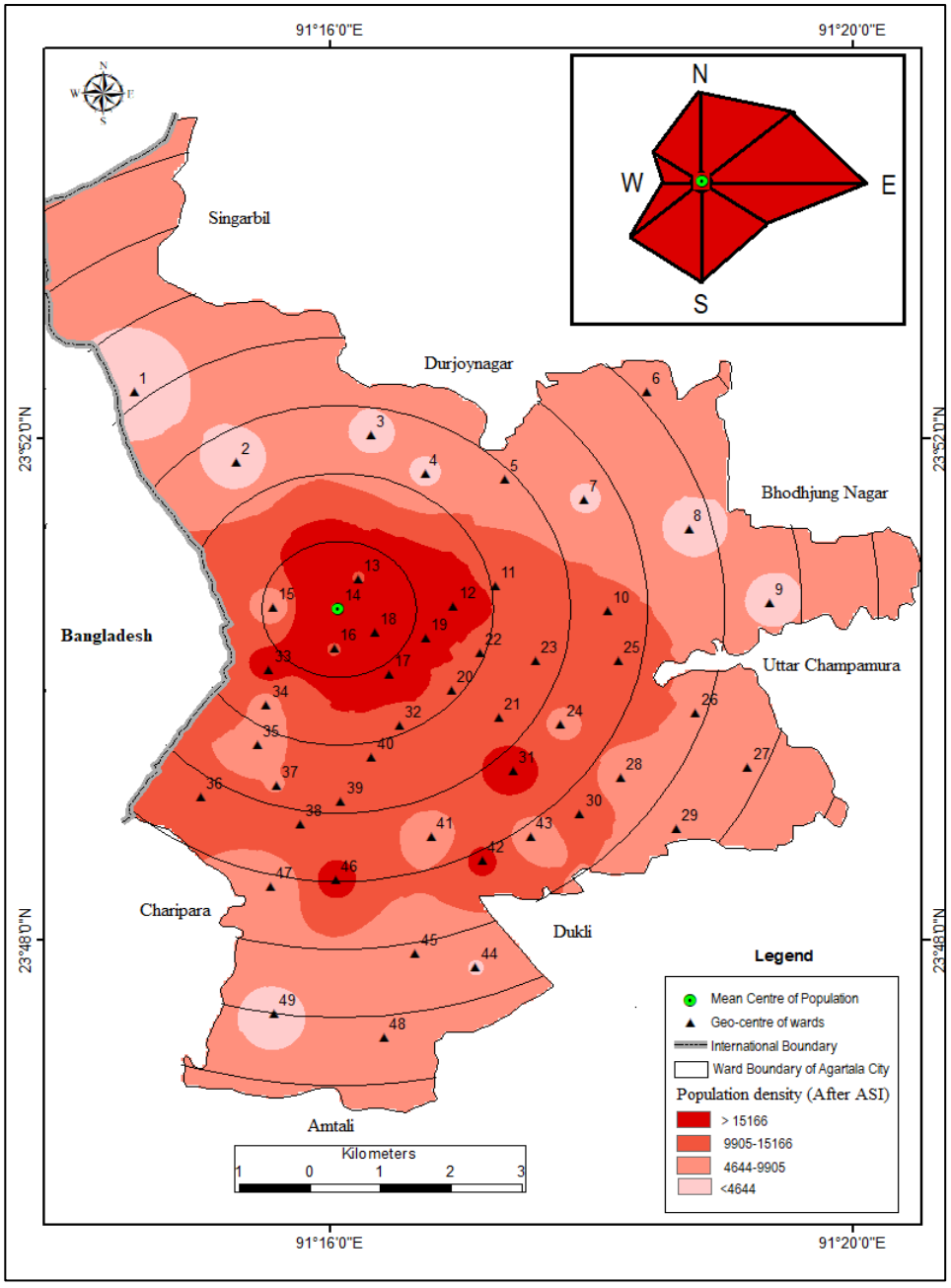



Source: Prepared by the authors, 2021

The spatial distribution of population density reveals that Agartala City follows a mono-centric population growth pattern (Fig. 4). The mean centre of the population is located in ward number 14. Ward number 14 (Ramnagar) is a planned residential area (planned almost 100 years back) encircled by road no. 7 and 9, i.e., Gangail Road and Ronaldsay Road. With increased distance from the mean centre, ward-wise population density has significantly reduced (Fig. 4).

**Figure 4**

*Spatial Distribution of Population Density of Agartala City*




Source: Prepared by the authors, 2021

Ward numbers 14, 17, 12, 33, 18 and 19 have very high population density, with more than 15,166 persons residing per sq. km. The area is located within 2 km from the mean centre of the city's population except for 31, 46 and 42 number wards

located in the further southern part of the city. Ward number 17 (0.510 km²) is the oldest part of the city. Most of the Ministers' and officers' quarters are in this ward. Further, Akhaura Road and Ronaldsay Road, the two major roads, are located in this ward. Ward number 31 (West Pratapgarh) is located on the right bank of river Haora, where the population density is 22,598 persons/ km². Ward number 12 is located on the northern bank of the Kata Khal River, with three significant settlement pockets: Krishna Nagar, Radha Nagar and Abhay Nagar. The VIP road is located at the centre of these wards. Ward number 46 is located on the south bank of river Haora, and NH8 move on the right side of the city where the population density is 17,572 persons per km². Matripalli [23°18'14" N and 91°16'18" E], Adarsha Pally [23°48'23" N and 91°16'12" E] and Milan Chakra [23°48'48" N and 91°16'12" E] are the main residential area of this ward. Integrated Check Post (ICP), Agartala [23°50'24.57" N and 91°15'1.33" E], located in the western part of ward number 33, which is the most important transit node between India and Bangladesh. TGA of ward number 33 is 0.570, where 9675 persons reside. Agartala-Akhaura Road is the main road of this ward. East Pratapgarh (ward number 42) is located on the northern side of the bypass of NH8, where the population density is 16,774. Ward number 18 is located on the south bank of Kata Khal. In ward number 18, both low and high-standard houses are found. Along the Kata Khal, a few slum settlements have been identified. On the other hand, high-rise buildings are observed along Ronaldsay Road, Harish Thakur Road and Pragati Road, and these areas combined contribute to high population density. Ward number 19 also experiences a very high population density of 15,469 (Fig. 4).

High population density has been found in the following wards, i.e., 11, 38, 16, 13, 21, 22, 40, 25, 23, 20, 39, 30, 36, 10 and 32. Ward number 11 (Ujan Abhoynagar) has been observed to have a high population density. The ward is located on the north bank of the river Kata Khal. Ward number 38 (A.D. Nagar) has been observed with 14,384 population. It has been observed that the population density of ward number 16 (Joynagar) is 14,247 persons/km². The mean population centre is within 1 km of the geocentre of ward 16 (Fig. 4). The Bhati Abhoynagar area falls under ward 13, where the population density is 14,216 persons/ km². With a 0.410 km² area and 6,378 population, ward number 21, with a high population density (14,191 persons/ km²), is located between River Haora and Kata Khal. Ward number 22 is adjacent to ward number 21, with its southern boundary and a population density of 14,096 persons/km². The TGA of ward number 40 is 0.770, where about 10,340 people reside per km². Geographically, this ward is located in the southern part of river Haora. Ward number 25 is located at the eastern fringe of Agartala City. The Dhalesware area and part of Kalyani are under ward number 25, with a high population density (13,200 persons/km²). Banamalipur area comes under ward number 23, which extends 0.84 km² Total Geographical Area (TGA) along with 10,784 population per km². Ward number 20 is between the River Kata Khal and the River Haora. The northern part of the ward was covered with the old settlement

pockets of the city like the Ujayanta Palace [23°50'14.40" N and 91°16'58.07" E] and its surrounding Laxminarayanbari and Jagannathbari area. On the other hand, Madhyapara is a comparatively new urban settlement area. The cumulative population of northern and southern parts makes this ward highly densely populated. Ward number 39 (East Bordowali area) has been observed to have a high population density (12,085 persons/km$^2$). NH-8 is moving from north to south from this ward. It has been reported that with a population density of 10,680 persons/ km$^2$, ward number 30 holds the 21$^{st}$ position among 49 wards of Agartala City. The population density of Ward 36 is 10,590 per km$^2$, located in one western part of the city. This ward shares about 0.64 km international boundary with Bangladesh. Inward number 10, settlements are scatteredly developed except the Reshambagan area due to the proximity of NH-8 and the location of the Inter-state Bus Terminal (ISBT) [23°50'11.72" N and 91°18'17.91" E]. The maximum area of ward number 10 is covered with agricultural land; apart from a few pockets, the population density is 10,404 persons/km$^2$. Ward number 32 was observed with a population density of 10,190 persons/km$^2$.

In Agartala City, population density is relatively low in 16 (38.78%) peripheral wards. These wards are 26, 37, 28, 24, 34, 43, 35, 41, 29, 15, 47, 6, 5, 27, 48 and 45. About 53 per cent of wards are located at the city's outer fringes except 15, 24, 26, 34, 35, 37, 41 and 43. The population density in those wards varies from 4,644 to 9,905 persons/ km$^2$ (Fig. 4). In Aralia (ward No. 26), about 9,707 people reside within the area of 0.98 km$^2$. Jogendranagar market [23°48'57.87" N and 91°18'27.80" E] and surrounding areas in ward number 28 have 9,017 persons/km$^2$. Similar results have been found in other wards of this group, where population density is between 8,882 and 15,707 persons per sq. km (Fig. 4). The maximum number of wards is between 1.5 km and 5 km away from the city's mean centre.

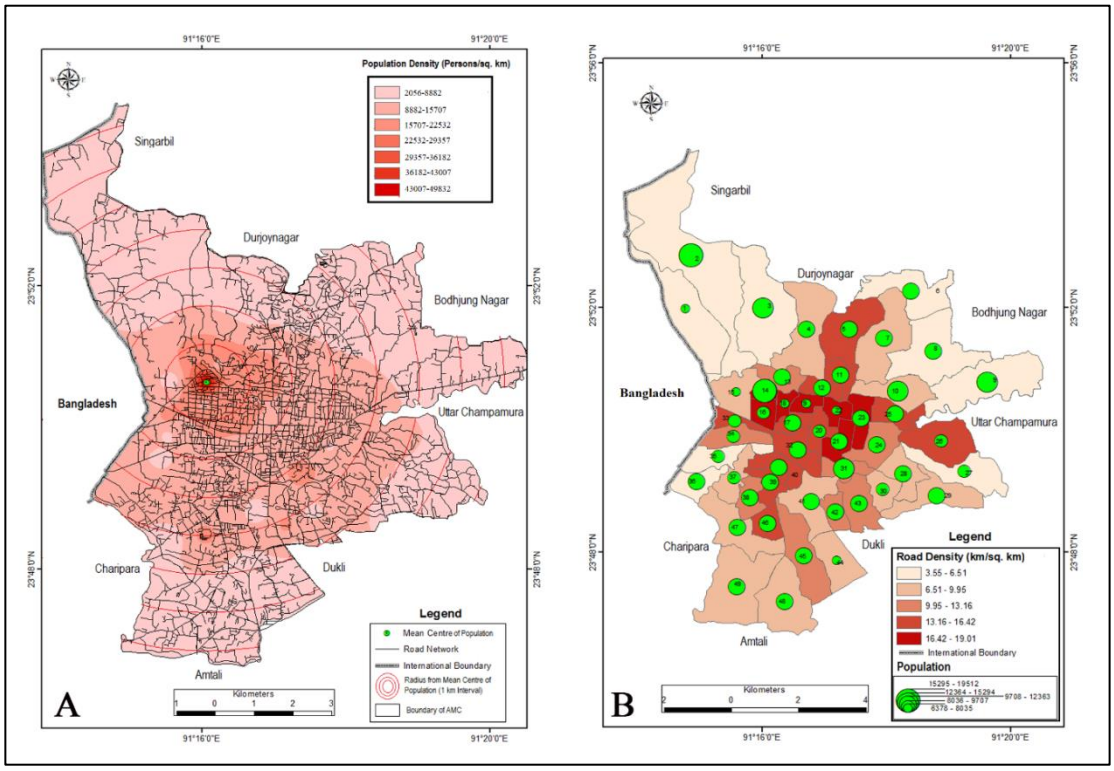
Very low population density is found in the few pockets of 44, 7, 9, 4, 3, 8, 49, 2 and 1, where population density is below 4,644 persons/km$^2$ (Fig. 4). Locational factors and lack of road network are the major reasons for very low population density in those wards.

It has also been observed that the international border between India and Bangladesh plays a significant role in the centrality model of population distribution (Fig. 4). The natural development of the centrality model has been restricted due to the location of the Indo-Bangla International border.

Road networks are the primary factors affecting urban development patterns (Roy & Ciobotaru, 2023; Iacono & Levinson, 2016). The average road density of Agartala City is 11.512 km/km$^2$. The highest road density (19.018 km/km$^2$) is found in ward number 16 of the city, where population density is also significantly higher (14,248 persons/ km$^2$).

**Figure 5**

*(A) Spatial Distribution of Road Network (B) Road Density and Population Distribution of Agartala City*




Source: Prepared by the authors, 2021; Data extracted through GPS Survey, 2020-21

It has been found that the road network is very high in the surrounding areas of the mean centre of the population (18.854 km/km²). On the other hand, the road network becomes thinner towards the city's outer circuit with a proportional reduction of population density (Fig. 5A). In the central part of Agartala City, the road network has a relatively higher population density. It has been observed that road density is normally higher in the central part of Agartala City (Fig. 5B).

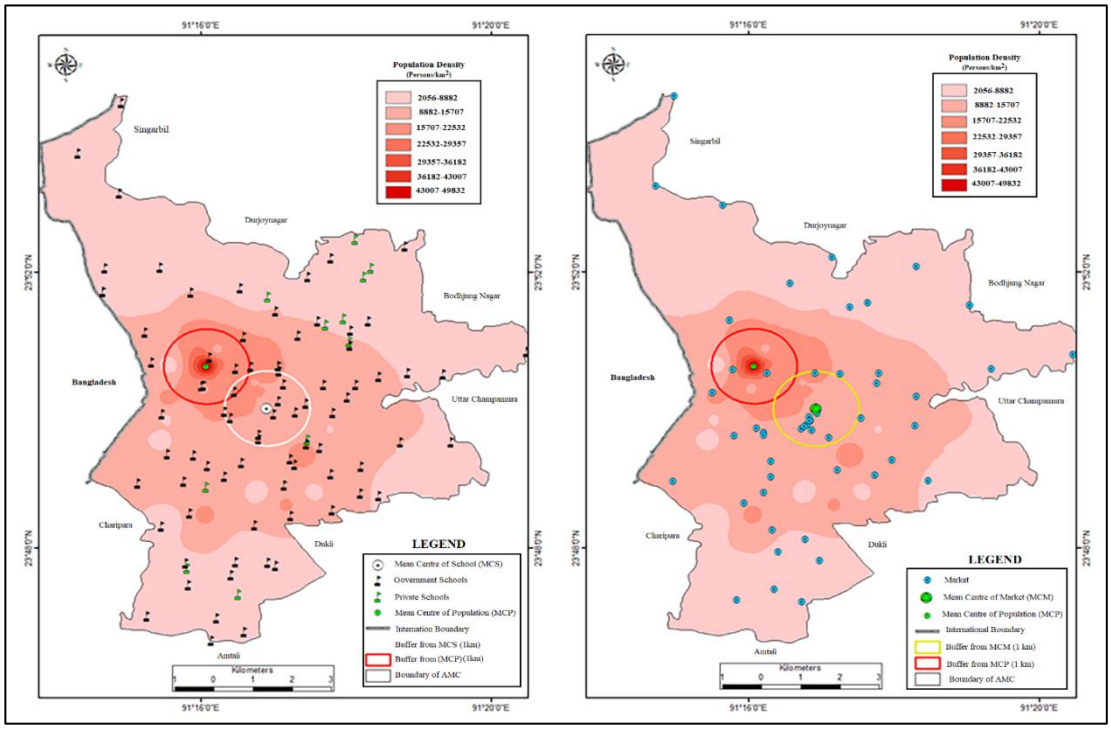
Educational institutions, especially schools, play a pull factor in population concentration. It has been found that most schools are located near the CBD area of Agartala City. Few private schools are established in the northern part of the city due to the availability of land (Fig. 6A). Few new settlement areas like Nandan Nagar [23°52'25.42"N and 91°19'48.91"E], West Noabadi [23°51'53.60"N and 91°19'0.28"E] has been developed nearby these schools.

On the other hand, the market also plays a significant role in population concentration. Most of the big markets are located in the central part of the city, where the road network is comparatively higher. The population of the wards close to the CBD area tends to increase compared to wards away from the CBD area. Still, the

difference in the population increase of neighbouring wards has been visible for some time. The reasons may vary. It may happen due to the location of those wards, distance from the school, market, workplace place, quality of communication, and other infrastructure. A comparative study may enlighten as reasons.

**Figure 6**

*(A) Spatial Distribution of Schools (B) Markets with the Population Distribution of Agartala City*




Source: Prepared by the authors, 2021; Data extracted through GPS Survey, 2020-21

Concerning the city, the degree of connectivity is also considered a variable representation of the road network. A correlation test has been performed and reported to find the correlation between the road network (degree of connectivity) and population density (Table 3). In Agartala City, population density and degree of connectivity have a significant negative correlation (Table 3).

It has also been observed that in Agartala City, schools and markets are primarily located in the central part of the city (Table 3). Few private schools are established in the northern part of the city (Fig. 6A). New settlement concentration may shift towards the north. Three significant markets, namely Maharaj Ganj Bazar, Battala Bazar and Lake Chowmani Bazar, are located in ward number 21, 16 and 19, respectively, and the corresponding population density of those wards are 14,191,

14,248, and 15,469 persons/ km² depicts that market is an influential factor of population density (Fig. 6B).

**Table 3**

*Spearman's Rank Correlations Between Population Density, Degree of Connectivity, Schools and Markets*

| | | | Population Density | Degree of Connectivity | Schools | Markets |
|---|---|---|---|---|---|---|
| Spearman's rho | Population Density | Correlation Coefficient | 1.000 | -.377** | -.378** | -.205 |
| | | Sig. (2-tailed) | . | .008 | .007 | .157 |
| | | N | 49 | 49 | 49 | 49 |
| | Degree of Connectivity | Correlation Coefficient | -.377** | 1.000 | .305* | .268 |
| | | Sig. (2-tailed) | .008 | . | .033 | .062 |
| | | N | 49 | 49 | 49 | 49 |
| | Schools | Correlation Coefficient | -.378** | .305* | 1.000 | .309* |
| | | Sig. (2-tailed) | .007 | .033 | . | .031 |
| | | N | 49 | 49 | 49 | 49 |
| | Markets | Correlation Coefficient | -.205 | .268 | .309* | 1.000 |
| | | Sig. (2-tailed) | .157 | .062 | .031 | . |
| | | N | 49 | 49 | 49 | 49 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

## Conclusion

Agartala is the state capital, the most densely populated area, and has a heterogeneous distribution. The classification of heterogeneity has been measured by an Alternative Synthetic Indicator and found efficient compared to the existing one to measure population distribution. With the increase in population, the distributional pattern has also changed significantly. The causalities of unequal population distribution mainly depend on the road network, especially the connectivity and the proximity of markets and schools. The recent planned development phase is marked by opening up the educational institutions in the city's outer circuit, the industrial zone on the outskirts, and infrastructural facilities reshaping the urban settlement pattern as a human landscape.

Population distribution is the most crucial decision-making factor for resource allocation, allotment and apportionment, which helps in policy decisions.

Efficient population distributional measures have been required for a more solicited decision support system. The suggested Alternative Synthetic Indicator (ASI) is a more efficient measure of population distribution over the existing Synthetic Indicator (SI). An Alternative Synthetic Indicator (ASI) is a preliminary decision support system for resource allotment and urban planning and development policy decisions. It also helps to classify the direct influence area with the degree of population density and infrastructural development with future prognostication.

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# Impact of Seasonal Rainfall Variation on People's Work Schedule in Extreme Humid Areas: A Case Study in Pynursla, Meghalaya

**Andy T.G Lyngdoh[1] and Subrata Purkayastha**

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**Abstract:** Climate change, increased pollution levels, and a shift in global atmospheric circulation have resulted in drastic changes in different seasons, affecting the livelihood of people with low incomes in rural areas. The present work focuses on the impact of seasonal rainfall variation on the rural livelihood of people in the Pynursla area. It examines the seasonal variation of rainfall and people's working hours by conducting a household survey to analyse how people respond to the seasonal variation of rainfall. Understanding the link between seasonal variations in rainfall and people's work schedules can lead to better planning, including the search for alternative sources of livelihood and other natural resources as income-generating assets that will help generate a regular flow of income leading toward sustainable development.

***Keywords***: climate change, seasonal rainfall, rural livelihood, work schedule, sustainable development

Seasonal variations of rainfall in different rainfall regimes vary over time and space. Although the monsoon affects most parts of India, rainfall varies from heavy to scarce in different areas. More than 80 per cent of the annual rain falls in the four rainy months from June to September (monsoon season).

The seasonal variation of rainfall affects the lives of farmers, business owners, and manufacturers in terms of the income earned from their source of livelihood.

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Furthermore, if such variation corresponds to the farmer's predictions, it results in a better harvest, high agricultural productivity, and profits. On the other hand, if seasonal rainfall variability is low or extremely high and does not match farmers' forecasts, this leads to the failure of agriculture, businesses, and other livelihoods, resulting in social, economic, and political chaos.

Located on the southern slopes of the Meghalaya plateau, Pynursla experiences an extremely humid climate. The War people, which are the sub-groups of the Khasi community (Schedule tribe), inhabit this part of the plateau, whose livelihood practises are in direct response to the variation of rainfall in different seasons as they live close to nature (Lyngdoh, 2018), where modernity is recent. The Inter-governmental Panel on Climate Change Report 2007 observed that rainfall patterns such as an early or late start of the monsoon, increasing variability of rainfall with alternating periods of too little or too much rain, and a general shift in the seasonal patterns are essential dimensions of climate change and have a considerable impact on the people in South Asia (Mackay, 2008).

Mikias Biazen (2014) observed that the local people of Ethiopia's Central Rift Valley Region depend on the Maher rainfall for crops like wheat, maise, and barley. However, the frequent delays in the rain and seasonal variations cause crop failure, resulting in low income and making them vulnerable to climate change. A similar study conducted in Bangladesh, where traditional agriculture still plays a vital role, reveals that the failure of the monsoon to arrive at the right time, as expected by the farmers, leads to crop failure and an increase in food prices (Etzold et al., 2014). Janakaraj et al. (2014) pointed out that most farmers in the Janjgir-Champa district of Chhattisgarh experience a decline in their income associated with crop production due to the change in rainfall pattern and a shift in seasonal variation of rainfall in terms of delay or onset impacting working hours, loss of work, food consumption, and security.

From their study in Jamaica, Spencer and Urquhart (2021) reveal that extreme climate events, such as incessant rainfall over a prolonged period, significantly impact absence from work and reduced working hours. However, the extreme climatic events do affect the absence of work of the people engaged in the secondary and tertiary sectors to some extent. However, the people engaged in the primary sector suffer when extreme climatic events occur, as their livelihoods depend directly on nature. The climatic elements, particularly rainfall, play a vital role in the people's work schedule, agricultural produce, and income generation derived from the primary livelihood practises (Lyngdoh, 2018).

Blackmore et al. (2021) discovered that the unpredictability of precipitation influences the subsistence farmers in the Guangaje region of Ecuador, resulting in a cyclical shift in agricultural productivity. According to research participants, climate unpredictability has caused shifts in planting seasons and consequently impacted food output. Further, according to a review of the composite seasonal calendar, households are food insecure for approximately 80% of the year, resulting in food

insecurity and seasonal hunger. The pressure on agricultural production limits households' ability to make enough money from farming to expand their financial and physical capital and make efforts to enhance or change their livelihood strategy. Because agricultural production is declining due to the unpredictability of precipitation, the heads of household, primarily men, relocate temporarily, seeking other sources of livelihood to earn money to fund expenses and other consuming demands. Furthermore, the study's findings indicate that seasonality is a crucial component of Guangaje's vulnerability setting affecting the farming community. Hence, various interventions to improve livelihood outcomes in these communities are necessary.

The present paper attempts to assess how seasonal variation in rainfall impacts the work schedule of the rural folk living on the southern slopes of the Meghalaya plateau, who have diversified livelihood practices. This study will help appraise how the seasonal variation of rainfall affects the working schedule of the people and their livelihood practices, as understanding this fundamental link between seasonal variations in rainfall and the working hours of people engaged in various livelihood activities can lead to better planning and enable people to search for alternative sources of livelihood that will help generate a regular flow of income, especially during prolonged incessant rainfall periods.

**Objective**

To assess the link between seasonal variation in rainfall and the working schedule of the head of household (the primary bread earner) engaged in different livelihood practises in the Pynursla area.

**Research Question**

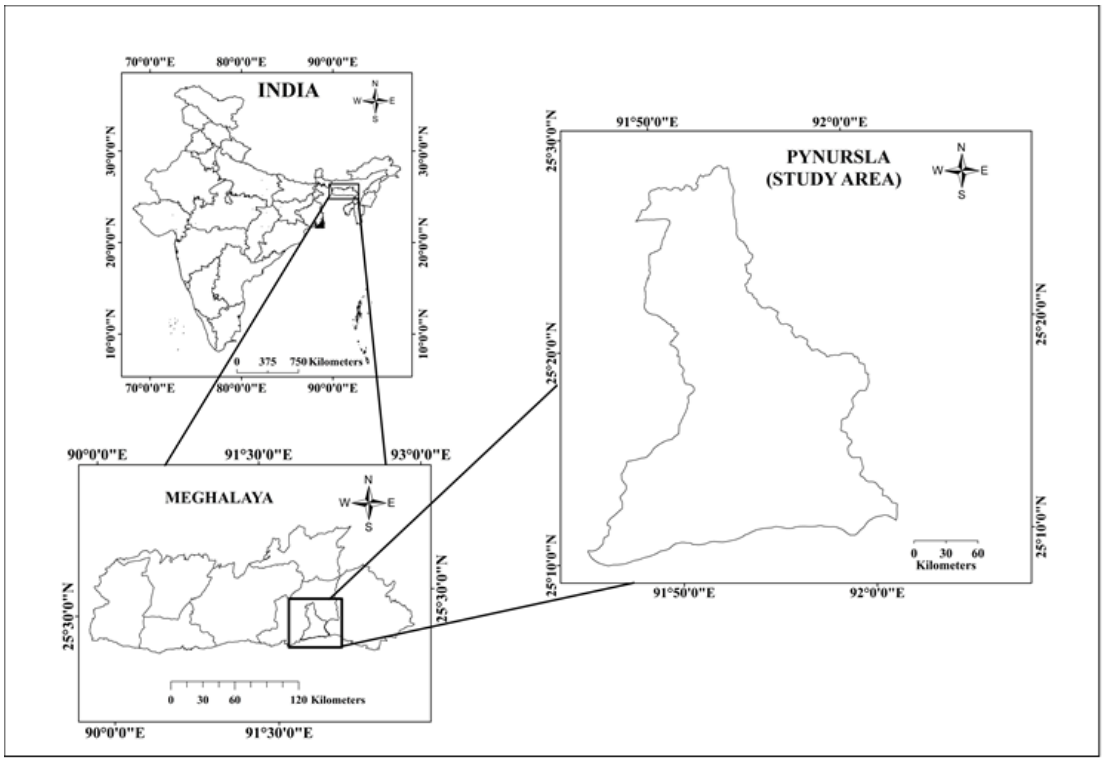
Is there a marked linkage between the seasonal rainfall variation and the head of household (the primary bread earner) work schedule in the Pynursla area?

**Regional Setting**

Situated on the southern slopes of the Meghalaya plateau, Pynursla is bounded by Mylliem Community & Rural Development (C&RD) Block to the north, Bangladesh to the south, Shella Bholaganj Community & Rural Development (C&RD) Block to the west and Amlarem Community & Rural Development (C&RD) Block to the east (Kharmyndai, 2013). The area chosen for this research lies under the jurisdiction of the Pynursla Community & Rural Development (C&RD) Block and falls under the administration of the East Khasi Hills District. The areas extend from 91°53'11.855" to 91°55'2.83" east longitude and 25°18'7.027" to 25°19' 11.759" north latitude, as shown in Figure 1.

**Figure 1**

*Location of the Study Area*




Besides being a hilly terrain, the study area has unique physiographic diversities characterised by undulating slopes and a rugged terrain where the south-flowing streams have brought many changes to the landscape. The altitude of the area is about 1500 meters above sea level. The topographic features suggest youthful relief produced by the rejuvenation of the old peneplain surface during the post-Eocene period, and this is evident from the occurrence of land features termed the Jaintia formation (Dikshit, K. R. & Dikshit, J. K. 2014, p.122).

The geological and physical structures significantly control the drainage and drainage patterns of Pynursla and follow parallel and trellis drainage. Numerous rivers, such as Um-Sohra, Um-Rem, Um-Song, Wah-Rew, and Wah-Pathaw, drain the Pynursla region and are perennial, owing to the existence of springs. In contrast, the smaller streams are non-perennial, flowing only in the summer when precipitation is high, especially with the onset of the southwest monsoon. Further, the alluvial, loamy, fine-loamy, and coarse-loamy soil characterises the Pynursla region, where the slope gradient, vegetal cover, and surface runoff greatly influence the soil structure and formation. Experiencing a highly humid climate, evergreen trees, deciduous trees, shrubs and ground vegetation, including lichens, mosses and climbers, dominate the vegetation of the study area. The main species found

are *Myrica Esculenta, Cinnamomum Tamala, Cedrela Toona, Betula Alnoides, Mohonia Pycnophylla, Commelina benghalensis, Artemisia spp* and Lantana camara (Kayang et al., 2005; Tynsong & Tiwari, 2010; Tynsong et al., 2012).

Pynursla is a region characterised by the highest annual rainfall in the world (Rakhecha & Clark, 1999). The study area is predominantly a rural block where the tribal population still lives near nature. Moreover, lying on the southern slopes of the Meghalaya plateau, the region experiences a highly humid climate with a distinct wet season (Lyngdoh & Ryntathiang, 2023) and heavy torrential downpours, especially during the peak monsoon seasons, limiting agriculture-dependent livelihoods and non-farm-based livelihood practises and affecting the work schedule of the people here.

## Data Sources and Methodology

The Meteorological Data Archive of Bangladesh/Northeast India provided the daily rainfall data of Pynursla station for the last four years (2013–2016) and calculated it on an average monthly basis. In addition, from the average monthly rainfall for four years (2013–2016), the different seasons, namely the pre-monsoon (March to May), monsoon (June to September), post-monsoon (October to November), and winter (December to February) (Taher & Ahmed, 1998), mark and analysed. The generation of empirical data for this paper was retrieved through a field survey carried out from 2013 to 2016; hence, the rainfall data also corresponds to this period. Further, the current observations reveal that there have not been many significant changes in the seasonal variation of rainfall in recent years, nor has there been much development work in the Pynursla area, as the rural people here continue to live close to nature, where the seasonal variation of rainfall plays a significant role in the work schedule of the villagers.

Secondly, the identified and selected villages for the survey are Madanshatsngi, Nenggate, Pynursla, and Umkor, which fall under the jurisdiction of Pynursla C&RD Block. Further, four focus group discussions took place in the selected villages with the village elders, consisting of the headman (Rangbah Shnong) and the executive members of the Village Panchayat (Dorbar Shnong).

Thirdly, for the generation of the socio-economic data and work schedule data of the population living in the Pynursla area, a household survey of the selected villages, namely Madanshatsngi with a total of 160 households (2011 census), Nenggate with a total of 171 households (2011 census), Pynursla (Iew and proper) with 250 households (2011 census), and Umkor with 266 households (2011 census), was conducted with the help of a semi-structured questionnaire, where the technique followed was random sampling, surveying 40 households from each village in the study area. Further, to analyse how seasonal variation in rainfall affects the working hours of the head of household (HH), 40 respondents who were the HH representing 40 households responded to the semi-structured questionnaire in each of the selected villages.

## Discussion

### Socio-economic Profile of the Head of Household (HH) or Respondent in the Four Villages

The Household survey conducted for 40 households in each selected village reveals that most HHs or respondents belong to the War Khasi community. However, an insignificant segment of the population, i.e., 2.5 per cent of the total surveyed households in Nenggate village, belongs to the Assamese-speaking community. It is interesting to note from the household survey that 57.5 per cent and 55 per cent of the HH are females in Umkor and Pynursla villages. In comparison, 87.5 per cent and 65 per cent of the HH or respondents are males in Nenggate and Madanshatsngi villages, respectively.

The HH in all the selected villages live in their own houses, and most of the respondents and their family members practice Christianity as their religion. However, in Madanshatsngi and Nenggate villages, 50 per cent and 47 per cent of the respondents, respectively, report that they still practice the traditional religion (i.e., Seng Khasi and Seng Raid).

Regarding the HH's literacy status and educational qualifications, the result reveals that the educational qualifications vary from illiterates to graduates. The survey suggests that Umkor village has the highest share of dropouts and illiterates, accounting for about 72.5 per cent and 15 per cent, respectively. The HH in Madanshatsngi village has a literacy rate of only 30 per cent, with 70 per cent of students dropping out at various stages in primary and secondary levels of education. Interestingly, Nenggate and Pynursla villages record the highest percentage of literate HH, accounting for about 52.5 per cent and 45 per cent, respectively. Further, the survey in the four selected villages reveals that the Thabah, the Khongthaw and the Tynsong clans own most of the farmlands. These clans, along with the Village Panchayats (Dorbar Shnong), look after the land and associated disputes so that the maximum population within the clan have access to the common land and other resources like forests, rivers, etc., and derive diverse livelihood practices, thereby enhancing their income and nutritional levels.

The household survey suggests that tourism is slowly emerging as an essential alternative livelihood practice even in this remote area, where about 6.88 per cent of the respondents are giving out rooms for rent to tourists as the concept of bed and breakfast. Similarly, Government officials from different districts work in the Pynursla area and reside in rented houses given to them by the respondents or HH. Apart from tourism, the Government is playing a vital role in enhancing the income of the HH by providing 100 days of employment as an alternative source of livelihood for every financial year through the National Rural Employment Guarantee Scheme (NERGS) and Meghalaya State Rural Livelihood Society (MSRLS). Hence, this has

become an essential coping strategy for work loss during heavy and incessant rainfall and cold and dry winters.

## Work Participation Rate in the Four Villages

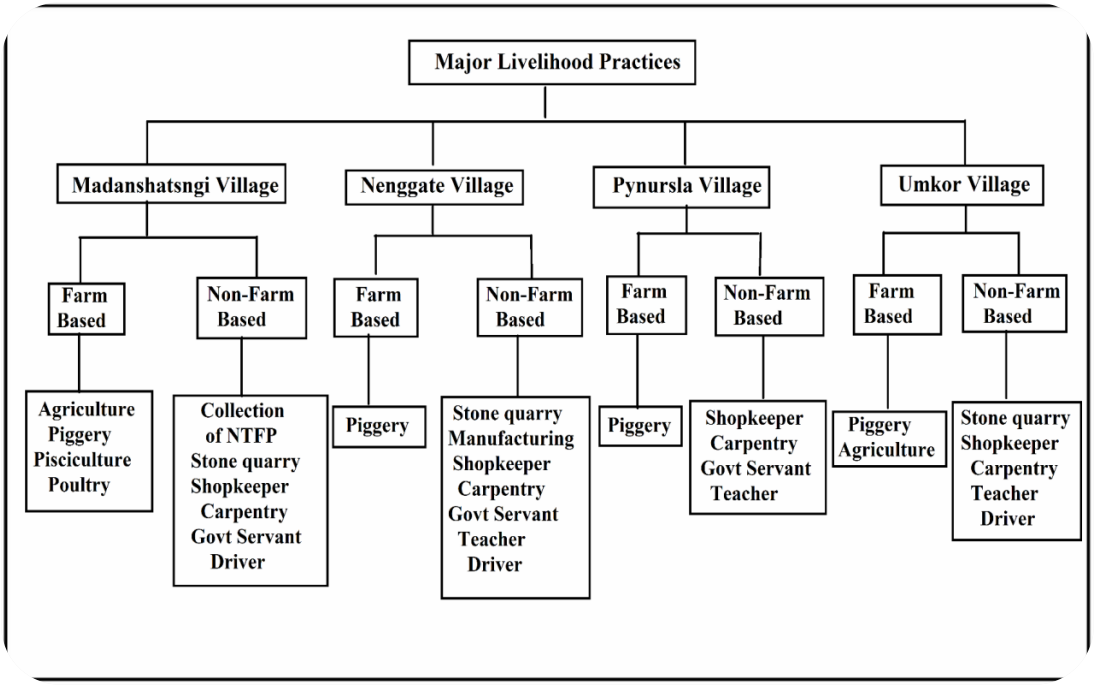
This section highlights the work participation rate of the HH engaged in different livelihood practices in the four selected villages according to the 2011 Census Report,

The 2011 Census Report suggests that the villages of Nenggate and Madanshatsngi have the largest share of the main working population to the total working population, with 86.11 per cent and 77.04 per cent, respectively. Similarly, the villages of Pynursla and Umkor record the highest share of the marginal working population to the total working population, with 37.87 per cent and 33.69 per cent, respectively. Further, the Census Report reveals that the village of Nenggate has the maximum share of the non-working population to the total population with 74.04 per cent.

## Major Livelihood Practices of the Head of Household (HH) or Respondent in the Four Villages

### Figure 2

*Major Livelihood Practices of the Respondents in the Selected Villages, Pynursla Area*



For analytical convenience, the primary livelihood practises in the four selected villages are categorised into two types, namely farm-based and non-farm-based, as shown in Figure 2.

The household survey suggests that the HH practices 12 major livelihoods in the four selected villages (Table 2). Further, Table 2 indicates the share of the HH in each of the significant livelihood practices and suggests that very few respondents practice agriculture, piggery, poultry, pisciculture and collection of non-timber forest products as their primary livelihood as compared to business (shopkeeping), transport services (drivers), Government service and carpentry in the selected villages.

**Table 2**

*Major Livelihood Practices of the Respondents or Head of Household (HH) in the Four Selected Villages in the Pynursla Area*

| **Villages** → | Madanshatsngi | Nenggate | Pynursla | Umkor |
|---|---|---|---|---|
| Major livelihood practices | Share in % to total workers | | | |
| Agriculture | 10 | 0 | 0 | 2.5 |
| Piggery | 2.5 | 2.5 | 12.5 | 15 |
| Pisciculture | 5 | 0 | 0 | 0 |
| Poultry | 2.5 | 0 | 0 | 0 |
| Collection of NTFP | 7.5 | 0 | 0 | 0 |
| Stone quarrying | 5 | 2.5 | 0 | 5 |
| Manufacturing * | 0 | 12.5 | 0 | 0 |
| Shop keepers | 25 | 12.5 | 47.5 | 35 |
| Carpentry | 25 | 37.5 | 25 | 25 |
| Government Services | 2.5 | 17.5 | 10 | 0 |
| Teaching | 0 | 7.5 | 5 | 2.5 |
| Driver | 15 | 7.5 | 0 | 15 |
| **Total percentage** | **100** | **100** | **100** | **100** |

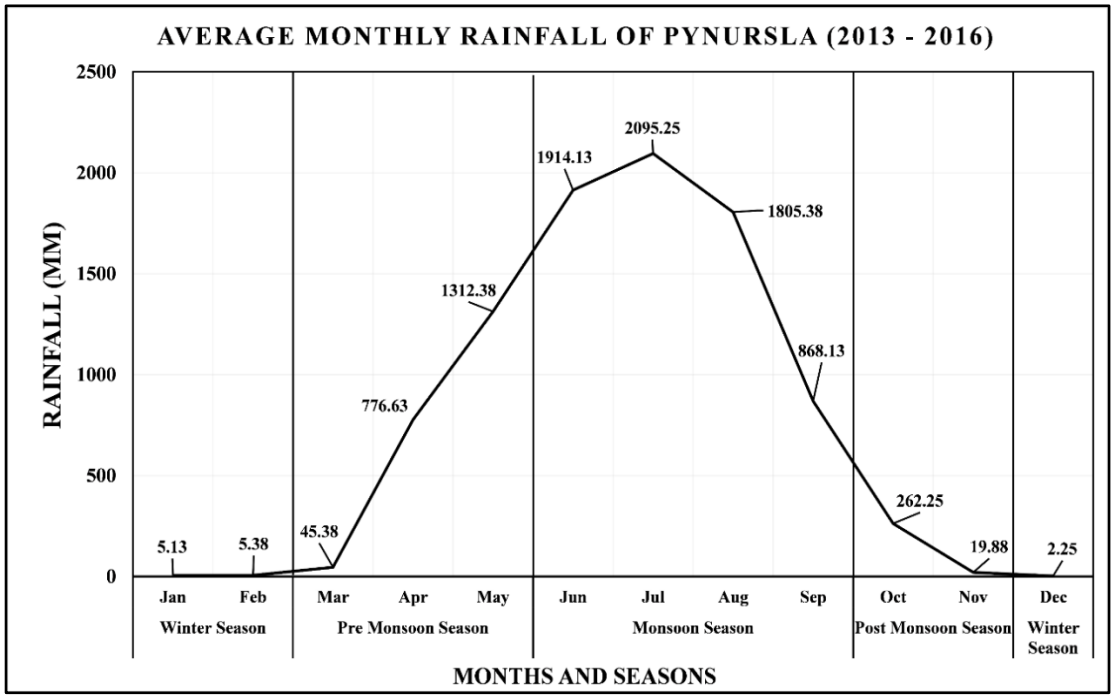
Manufacturing* of crude household items and farm equipment from scrap iron, welding and small-scale iron smelting.
*Source:* Household survey

## Link between the Seasonal Rainfall Variation and the Head of Household (HH) Work Schedule in the Selected Villages of the Pynursla Area

This section highlights the linkage between the seasonal rainfall variations and the work schedule of the respondents or HH in the selected villages of the Pynursla area. Figure 3 depicts a graphic of average monthly rainfall from 2013 to 2016 divided into distinct seasons to help understand such a link. Secondly, a graph showing the working schedule chart where the Y-axis represents the percentage of workers (head of household), and the X-axis represents the primary livelihood practices of workers in different seasons.

**Figure 3**

*Average Monthly Rainfall of Pynursla (2013 – 2016)*




Furthermore, this section discusses the link between the seasonal rainfall variations and the HH work schedule in the selected villages following colour schemes depicting the working hours of workers engaged in diverse livelihood practices.

### *Link Between the Seasonal Rainfall Variation and the Work Schedule of the HH in Madanshatsngi Village*

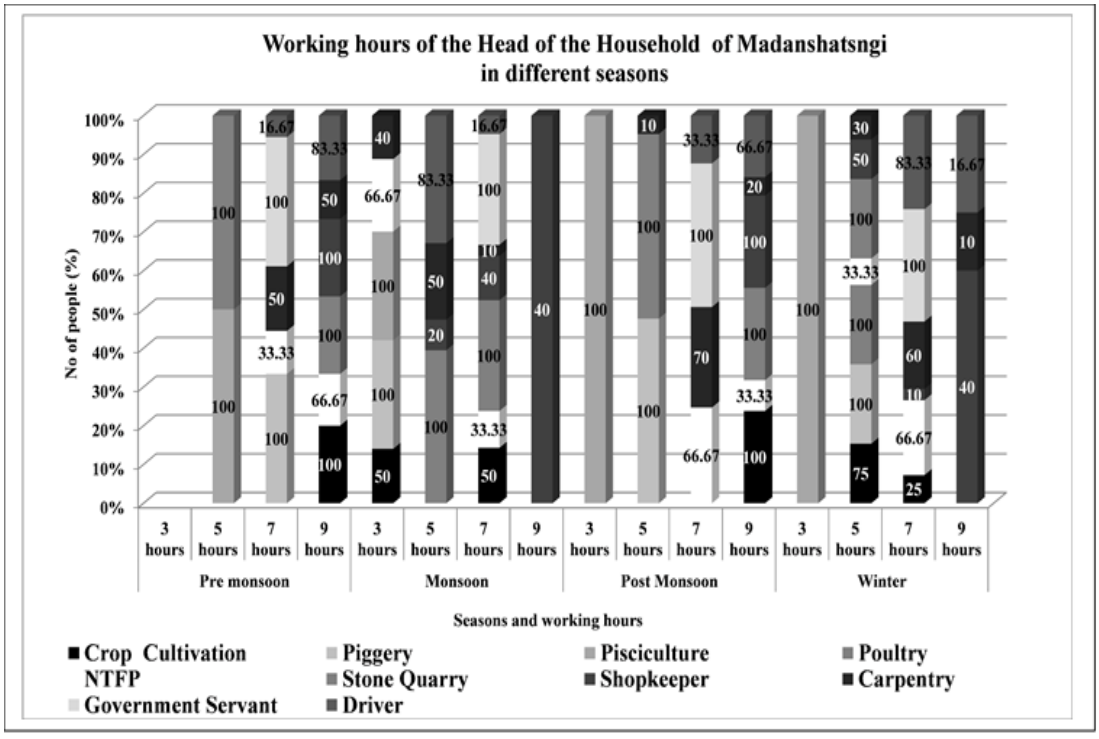
Figure 4 suggests that the HH in Madanshatsngi village practices ten significant livelihood practices. Ten per cent of the HH are engaged in agriculture,

working 7 hours a day during pre-monsoon and post-monsoon seasons. The farmers here work from 9 a.m. until 5 p.m. during the pre-monsoon and post-monsoon season. The main work of the farmers during these seasons is sowing (pre-monsoon) and harvesting the crop (post-monsoon). Field data suggest that during monsoon season, the farmers work for fewer hours in agricultural fields due to incessant rains, which significantly affects agricultural productivity, reducing the HH income to only rupees 2000-4000 per month. During the winter seasons, the HH reporting agriculture as their primary livelihood seeks other alternative sources of livelihood, like daily wage labour and the establishment of petty businesses to generate more income for sustenance. Further, to cope with the losses from crop failure due to incessant heavy rainfall during the monsoon season, the farmers get government

assistance from the C&RD Block office to procure fertilisers and seedlings at a subsidised rate.

**Figure 4**

*Working Hours of the HH of Madanshatsngi in Different Seasons*




With an income generation ranging between rupees 4000 to above 10,000 per month, the households reporting piggery, poultry, and pisciculture as their primary livelihoods work for 3 to 5 hours daily, and the seasonal rainfall variation does not hamper their work schedule. Survey reports reveal that the people engaged

in piggery and poultry complete their work during the morning hours. At the same time, during their free time, the HH diversifies their livelihood by engaging in other alternative sources of livelihood, including petty businesses and daily wage labour in the NERGS scheme, enabling the HH to earn an extra income, i.e., rupees 3000 extra per month. Further, the household survey results reveal that the HH engaged in the above livelihood practices gets support from the C&RD Block office to procure piglets and fingerlings at a subsidised rate.

Field data suggest that 7.5% of the HH collects non-timber forest products (NTFP) from Madanshatsngi village, working for 3 to 5 hours daily and earning about 300 rupees daily. Figure 4 shows that the work schedule of the HH engaged in the collection of NTFP is least affected by the average monthly rainfall during the pre-monsoon and post-monsoon seasons. During this season, the HH diversifies their livelihood by opening small shops and selling the collected NTFP product, earning an extra monthly income of rupees 1500 to 2000. During these seasons, 5 per cent and 2.5 per cent of the NTFP collectors work for about 3 to 5 hours daily. During the monsoon and winter seasons, due to heavy rainfall and cold, dry climatic conditions, the collection of NTFPs becomes difficult, and livelihood diversification becomes restricted.

Five per cent of the HH in Madanshatsngi village report stone quarrying as their primary livelihood; the HH engaged in this source of livelihood practice work for approximately 5 hours a day during the pre-monsoon, post-monsoon, and winter seasons. Since the HH income derived from this livelihood is only rupees 4000 to 6000 per month, the HH diversifies their livelihood, works as daily wage labour, and earns 2000-3000 extra. On the other hand, during the monsoon, which is associated with high rainfall ranging from 868.13 mm to 2095.25 mm, work in stone quarrying becomes difficult, affecting the income derived from stone quarrying.

During the pre-monsoon, post-monsoon, and winter seasons, household surveys suggest that the carpenter's work schedule remains unaffected, and they work for about 7 hours a day, earning rupees 4000 to 8000 per month. On the other hand, the field data suggest a reduction in the working hours of the carpenters during the monsoon season when heavy and incessant rainfall deters work efficiency as 7.5 per cent and 17.5 per cent of the carpenters work for 5 hours and less than 7 hours, respectively. Similarly, field data suggest that the work schedule of the HH engaged as shopkeepers is more during the pre-monsoon, post-monsoon, and winter seasons, as 12.5 per cent of the shopkeepers work for 7 to 9 hours a day earning rupees 4000 to above 10,0000 per month. Furthermore, if heavy and continuous rain persists, some shopkeepers lose as demand in the market decreases.

Figure 4 reveals that the average rainfall does not affect the work schedule of government servants. However, the work schedule of the drivers constantly changes according to the seasons and market days.

### *Link Between the Seasonal Rainfall Variation and the Work Schedule of the HH in Nenggate Village*

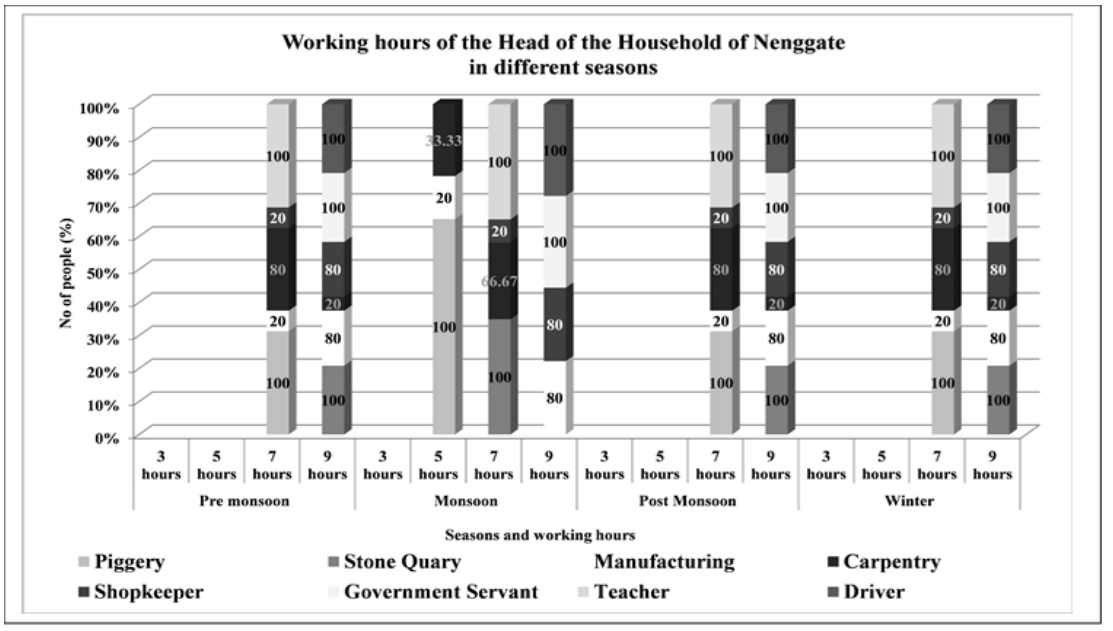
A field survey from Nenggate reveals eight livelihood practices. 2.5 per cent of the HH engaged in piggery farming work 3 to 5 hours a day during the pre-monsoon, post-monsoon, and winter seasons, earning rupees 4000-8000 per month. Field survey reveals that the HH get help from the C&RD Block office in buying piglets at a subsidised rate. Further, the HH also diversifies their livelihood and gets engaged as daily wage labour earning an extra income; however, during the monsoon season, the people engaged in this livelihood miss work as they can usually work from 9 a.m. until noon, as heavy rain usually arrives during the afternoon restricting livelihood diversification.

Field survey suggests that 2.5 per cent of the HH engaged in stone quarrying works for 9 hours a day and are least affected by seasonal rainfall except during the monsoon when the average monthly rainfall ranges between 868.13 mm and 2095.25 mm. In the quarry mines, work starts from 8 a.m. and continues till 5 or 6 p.m. during pre-monsoon and post-monsoon seasons; however, during the monsoon season, due to torrential rainfall, stone quarrying becomes difficult, and the daily wage labourers engaged in this livelihood practice have to seek for other alternative sources of livelihood.

Figure 5 reveals that 12.5 per cent of the HH are engaged in small-scale manufacturing, and the manufacturers work 7 to 9 hours daily during the pre-monsoon, post-monsoon, and winter seasons, earning around rupees 6000-8000 per month, on average. Further, the field report reveals that 2.5 per cent and 7.5 per cent of the small-scale manufacturers work 7 to 9 hours a day, respectively, unaffected by seasonal rainfall. However, during the monsoon season, the work schedule of these manufacturers diminishes to 5 a day due to heavy rainfall varying between 868.13 mm and 2095.25 mm on average. During this season, 2.5 per cent and 10 per cent of the manufacturers work only for 5 to 7 hours a day, respectively. The survey also reveals that heavy rainfall during this season results in frequent power cuts, making it impossible for manufacturers to use their tool, which runs on electricity.

**Figure 5**

*Working Hours of the HH of Nenggate in Different Seasons*




Field findings reveal that 12.5 per cent of the HH engaged in businesses are shopkeepers. The shopkeepers work for 5 to 9 hours a day. Further, during the pre-monsoon, post-monsoon, and winter seasons, 7.5 per cent and 5 per cent of the shopkeepers work for 7 and 9 hours a day, respectively. However, with heavy monsoon rainfall, the work schedule of the shopkeepers changes and reduces to 5 to 9 hours daily. Consequently, heavy rainfall restricts customers from coming out, and as a result, the income of the shopkeepers is reduced during this season.

Field survey reveals 37.5 per cent of the HH engaged in carpentry in Nenggate village, out of which 35 per cent and 2.5 per cent of carpenters work for 7 and 9 hours a day, respectively, and their work schedules are least affected by rainfall during the pre-monsoon, post-monsoon, and winter seasons. On the other hand, with an average monthly rainfall varies between 868.13 mm and 2095.25 mm during the monsoon season, 12.5 per cent and 25 per cent of the carpenters work 5 to 7 hours daily due to continuous downpours; this significantly affects the work schedule of the carpenters resulting to a decrease in the income earned.

From Figure 5, the field survey suggests that 17.5 per cent and 7.5 per cent of HH are government servants and teachers unaffected by the seasonal rainfall variation. Similarly, Figure 5 shows that 7.5 per cent of the people work as drivers. During monsoon season, the drivers work 7 hours a day, as heavy rainfall affects their work schedule. On the other hand, with the decrease in rainfall during the post-monsoon and winter seasons, the drivers continuously work for 9 hours.

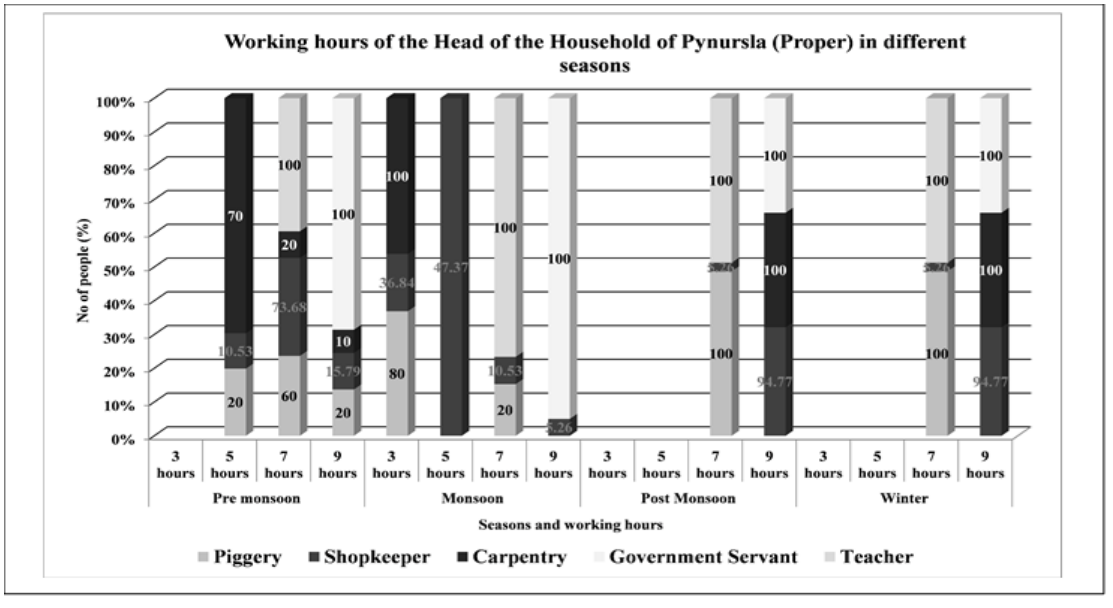
### *Link between the Seasonal Rainfall Variation and the Work Schedule of the HH in Pynursla Village*

The household survey suggests that HH practices five types of livelihoods in Pynursla village, most of which are non-farm-based activities. Figure 6 depicts that 12.5 per cent of the HH engaged in piggery farming work 3 to 5 hours a day, and their working schedule constantly changes according to the seasons. During the pre-monsoon, post-monsoon, and winter seasons, field surveys reveal that the HH works 5 hours a day, and the seasonal rain does not influence their work schedules. After completing their work, they diversify their livelihood and engage in petty businesses (small local shops), enabling them to earn an extra income. However, during the monsoon season, when the average monthly rainfall is high, their work schedule changes from 5 to 3 hours daily. Further, field survey reports suggest that only 2.5 per cent out of 12.5 per cent of the HH get help from the C&RD Block office in buying piglets at a subsidised rate.

Figure 6 shows that 47.5 per cent of the HH are shopkeepers, and their work schedule remains the same during the pre-monsoon, post-monsoon, and winter seasons, enabling them to earn rupees 8,000 to above 10,000. During these seasons, 7.5 per cent and 40 per cent of the shopkeepers work 7 and 9 hours a day, respectively. On the other hand, during the monsoon season, the work schedule of the shopkeeper changes; during this season, 10 per cent and 37.5 per cent of the shopkeepers work 5 and 9 hours, respectively, daily. Further, a field survey reveals that 10 per cent of the shopkeepers affected by the heavy monsoon rain work approximately 5 hours a day as most of their shops lack proper building materials and are in poor condition, affecting their income.

**Figure 6**

*Working Hours of the HH of Pynursla in Different Seasons*



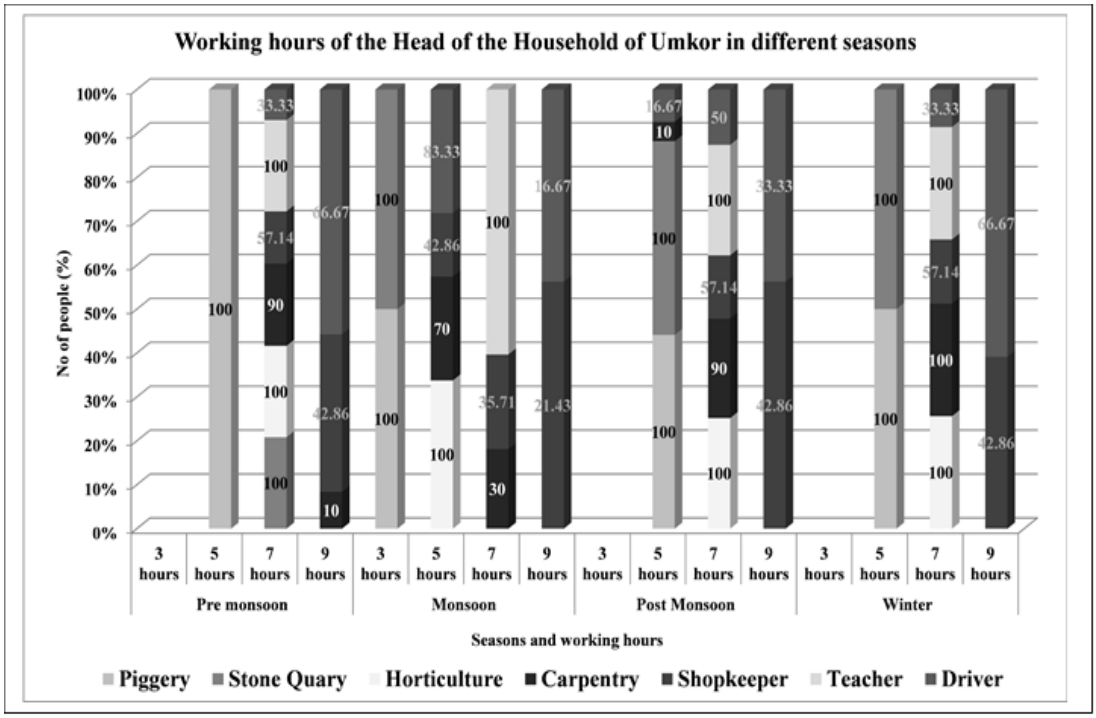
During the pre-monsoon, post-monsoon, and winter seasons, rains do not affect 25 per cent of the HH engaged in carpentry, and the carpenters work 9 hours a day, earning about rupees 6000 to above 10,000 a month. On the other hand, during the monsoon season, incessant rainfall affects the work schedule of the carpenters due to the poor condition of their workshops, resulting in a fall in the income earned. During this season, they work for 7 hours a day.

### *Link Between the Seasonal Rainfall Variation and the Work Schedule of the HH in Umkor Village*

Field survey results reveal that Umkor village reports seven types of primary livelihood practices. Figure 7 is illustrative in many ways. 2.5 per cent of the HH practices horticulture and mainly grows cabbage. The HH engaged in horticulture work 3 hours a day, and the pre-monsoon, post-monsoon, and winter rain does not affect the work schedule of the HH engaged in this livelihood practices, enabling them to diversify their livelihood to earn an extra income, which averages around rupees 4000 to 6000 per month. However, during the monsoon season, horticultural farmers cannot work in open fields due to heavy rainfall, affecting their income and livelihood.

**Figure 7**

*Working Hours of the HH of Umkor in Different Seasons*



Field findings suggest that 15 per cent of the HH engaged in piggery work for 3 to 5 hours and earned about rupees 6000 to 8000 per month. During the pre-monsoon, post-monsoon, and winter seasons, 5 per cent and 10 per cent of the HH engaged in piggery work of 3 to 5 hours a day, respectively. The HH diversifies livelihood during these seasons by working in construction sites to earn an extra income for a better standard of living. On the other hand, the incessant monsoon rains adversely affect the working hours of the HH engaged in this livelihood practice, where 7.5 per cent of HH work for only 3 hours, and another 7.5 per cent work for 5 hours a day, restricting livelihood diversification and reducing income generation during the monsoon season.

Five per cent of the HH work in stone quarries. During the pre-monsoon, post-monsoon, and winter seasons, the quarrymen work for 7 hours a day, enabling them to earn rupees 1500 per transport (per jeep); however, quarrying activities come to a standstill during the monsoon season because of the heavy rainfall, and this drastically affects their income and standard of living.

Thirty-five per cent of the HH engaged in businesses, mainly as shopkeepers, work 5 to 9 hours a day, generating a monthly income of rupees 4000 to above 10,000. Field surveys suggest that 15 per cent and 20 per cent of the shopkeepers work for 7 hours and 9 hours a day, respectively, and their work schedules are least affected by pre-monsoon, post-monsoon, and winter rains. On the other hand, there is a reduction in the working hours of the shopkeepers during the monsoon season because of heavy rainfall. Field data reveals that 25 per cent and 10 per cent of shopkeepers work for 7 hours and 9 hours a day, respectively, during the monsoon season, adversely affecting the income derived from these livelihood practices.

Twenty-five per cent of the HH in Umkor village work as carpenters, earning about rupees 4000 to 8000 per month. The HH works 7 hours a day without facing any problems during other seasons; however, in monsoon season, incessant rainfall limits the work schedule of the carpenters as frequent power cuts hamper their work. Moreover, the poor condition of the workshops limits their working hours, adversely impacting their income and livelihood.

Further, 2.5 per cent of the HH engaged in teaching work 7 hours a day, earning about rupees 6000 to 8000 per month, and their work schedule remains constant in all seasons. Similarly, 15 per cent of drivers' work schedules are unaffected by pre-monsoon, post-monsoon, and winter rains, and they work 7 and 9 hours a day, respectively. On the other hand, during the monsoon season, due to heavy rainfall resulting in fewer passengers, the drivers' work schedule changes, where 7.5 per cent each work for 7 hours and 9 hours a day, and their daily income also gets affected.

## Results

During the pre-monsoon and post-monsoon seasons, field data from the household survey conducted in the selected villages reveal greater livelihood diversity among the respondents or HH. On the contrary, during the monsoon season due to heavy rainfall and during winter because of cold and dry weather, field data suggest limited livelihood diversification among the HH in the study area. Further, the field survey reveals that the HH work schedules constantly change as per the rainfall variability in the different seasons. Interestingly, except for teachers and government services, all other livelihood practices of the HH in all four villages report a loss of working hours, especially during the monsoon season followed by the winter. The heavy rainfall and the cold, dry conditions during the above seasons adversely affect their primary livelihood practices and income generation, unfavourably affecting their sustenance. Here, policy intervention is necessary to enhance alternative livelihood opportunities to generate income to maintain their families.

Further, the focus group discussion report reveals that families get Government and non-government assistance to cope with the adverse effect of seasonal rainfall variability. However, out of the total 160 households surveyed, only nine respondents whose primary livelihood practices are related to agriculture, piggery, pisciculture and horticulture reported that they got help from Meghalaya Rural Bank in the form of loans and from Pynursla C&RD Block Office to procure agricultural equipment's, fertilisers, piglets, and fingerlings (baby fishes) at a subsidised rate.

## Conclusion

Field survey significantly reveals a direct link between the seasonal rainfall variation with the major livelihood practices and the HH's working hours in all four villages. It is interesting to note that incessant torrential downpour almost every day during the monsoon season restricts the working hours of the HH and their various livelihood practices except for the HH engaged as teachers and government services. Similarly, in the winter season, due to the cold and dry climate, the working hours of the HH engaged in farm-based activities are relatively less when compared to pre-monsoon and post-monsoon seasons since during this time of the year, the agricultural lands in Pynursla are left fallow to regenerate its fertility for the next sowing season. Hence, the HH reporting farm-related primary livelihood practices reports shorter work hours as the days are also of short duration during the winter season, adversely affecting their income.

The HH, which reports the collection of NTFP, also report shorter working hours during the winter as the bay leaf trees, medicinal herbs, fruits, and other food items from the forests dry up and dwindle during this season. During the monsoon season, heavy torrential rainfall results in the luxurious growth of vegetation, making

the forest impenetrable to venture on the slopes of Pynursla, restricting the collection of NTFP, resulting in loss of working hours and limiting livelihood diversification; however, the winter reduces the working hours of the HH due to cold, windy days, making outdoor life difficult. The incessant rainfall during monsoon and cold, dry climatic conditions during winter affect the livelihood practices and income generation of the rural marginalised population, making it difficult to sustain their families. The Government has introduced the MSRLS scheme and the NERGS for the people, enabling them to get employment and enhance their income. However, the hour needs to create more alternative indoor-based livelihood practices, especially during the monsoon season.

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We thank Mrs. Inamorata Marbaniang for being a constant source of support. Appreciation also goes to the Bangladesh/North Eastern India Meteorological Data Archive on rainfall (Pynursla station) and the Block Development Officer of Pynursla for providing the necessary information and data about this research.

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# Mobility Patterns of Criminals in Chennai City, India: A Spatial Analysis

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**Abstract:** The pattern of journey by criminals varies from one part of the city to another. The analysis of the spatial movement pattern of offenders deserves closer attention. With the help of quality crime data, appropriate methodology, and the availability of GIS mapping techniques, this study aims to understand the travelling pattern of criminals in Chennai. The findings of this study demonstrate that the criminals' travel patterns when staging a crime are linked to the physical and functional aspects of various zones of Chennai. Criminals are more likely to travel longer distances to commit crimes in areas with limited environmental potential. On the other hand, because of increased environmental potential, the rate of occurrence of crimes is higher in commercial and high-income residential neighbourhoods, and criminals travel less in these regions. The maps created with GIS software identify the places where criminals travel at a high and low level. This type of identification could aid the police in making better law enforcement plans.

***Keywords:*** location preference, commuting of offenders, origin and destination of offenders, environmental opportunity

Crime geography deals with the study of the spatial and temporal distribution of crime incidences. Desired targets, crime types, operational convenience, and individual decisions decide the spatial movement of criminals. The journey to crime starts at the criminal's residence and ends at the place of operation. Criminals living in different parts of the city have different travel patterns related to differences

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within broader communities. Criminals' travelling patterns in a city are a unique type of general mobility. Investigating criminal and victim movement patterns is an important aspect of the spatial analysis of crime since movement patterns are dynamic (Brantingham & Brantingham, 1984, p. 237). Using spatial and temporal patterns of crime, we can better understand how different neighbourhoods attract different types of criminals and how such interactions influence the destinations and origins of criminals. The movement of criminals and things unavoidably expands the region where control is required. (Sutherland & Cressey, 1985, P.25). By examining the spatial behaviour of criminals in Madras, Sivamurthy (1975) made a pioneering contribution to crime geography. In this study, he investigated the travelling patterns of criminals in Madras, newly urbanised and older inner-city areas. The scope of this research was limited to property offences. According to this study, many criminals travel 5 to 10 kilometres to commit crimes. Later, Sivamurthy (1979) investigated the spatial pattern of travelling criminals in Madras City using Census divisions as area units and discovered that commercial centres and transportation terminals attract more criminals from far-off regions.

To investigate the relationship between criminal residence and other geographical variables such as land use and the built environment. Most crime events were found in areas with high unemployment rates and low middle-class incomes (Canter et al., 2000). A crime requires both offenders and targets to be present simultaneously. A criminal's intersection with their target in time and space. It covers their motivations, destinations, routes, distances, directions, modes of transportation, and travel companions (Bernasco, W. (2014).

Neighbourhoods of different socioeconomic statuses attract criminals' travel patterns (Bunting et al.,2018). The features of the home community are more important than those of the target community, while the features at the individual level are most influential. Older burglars travel longer distances to commit their crimes than younger ones. Group burglars tend to travel further than solo burglars (Xiao et al.,2018)

The travelling criminal's journey to crime has received much attention in mobility triangle research. In contrast, the travelling victim's journey and the distance between the residence of the offender and the victim have received less attention. Travel patterns are affected by the demographic characteristics of criminals and victims. Criminal behaviour also impacts travel patterns. The chances of crime are closely related to the distance between the residences of the offender and the victim (Luo et al. et al., 2021)

Previous studies have provided noteworthy insights into the behavioural characteristics of criminals, with different conclusions being drawn. However, the importance of choosing certain geographic areas over others for committing crimes due to their abundant opportunities or proximity to the criminals' residences has not been highlighted. This study has highlighted their significance, based on which the criminal’s travelling pattern is mapped, to provide a bird's eye perspective of a

criminal's choice of places from most to least preferred and the rationale behind it. The concept of commuting and the Relative commuting index were briefly examined to assess crime patterns.

The ultimate goal of this research is to map out crime-prone areas based on the loot worthiness of a location, a criminal's place of residence, and his place of operation, or, to put it another way, to conduct a spatial movement analysis of criminals and determine the correlation and statistical significance between socioeconomic development and criminals' willingness to leave an area of interest.

Geospatial analyses can help law enforcement better target prevention programs. Geographically, it is important to investigate the spatial patterns of offenders' movements since local components are essential. It is observed that criminal journey patterns vary from place to place, even when the type of offence is the same. Using GIS mapping techniques and enhanced data quality and methodology, the study aims to understand the mobility of criminals in the City of Chennai. It is heavily urbanised, with the highest population density, and has the highest crime rate in Tamil Nadu. Despite the uniqueness and severity of the crime problem, Chennai city was chosen for study.

## Data and Methodology

Chennai city had 7450 incidents of crimes in 2017, according to police station records (Figure 1). Data about the place of occurrence (Crime scene) and Location of the criminal's residence (Place of origin) along with the charged offence have been collected from the CRB (Crime Records Bureau) for 70 police stations in Chennai city.

A Chennai city map was compiled using EICHER maps, and georeferencing was performed using GIS tools software using Ground Control Points (GCP) of important locations in and around the city. With the georeferenced map, the Chennai City boundary could be accurately delineated, which assisted in demarcating the Police boundary. This study used a police boundary map for Tamil Nadu found in an article published by Sivamurthy (2005) (A study of spatial mobility of property offences, the Indian Police Journal) was used for the current study. To obtain the police boundary precisely, the map was traced and redrawn (Figure 2). We created a base map consisting of police station boundaries and police station locations.

GIS tools were used to plot the crime scene locations (Figure 1). After this, X and Y coordinates were generated for various crimes, such as theft, house burglary, pocket-picking, cycle theft, automobile theft, and chain snatching, and unique IDs were created for each crime. Next, the residences of the Criminals were plotted, and then the origins and destinations of their trips were identified.

Origin and destination reveal much about the spatial dynamics of movements and interactions. In order to analyse the attractiveness of the area in terms of the

movement of offenders, a Commuting index (CI) was calculated. The reason an individual commutes from one area to another is believed to be a lack of opportunity in his area

**Figure 1**

*Spatial pattern of Property crime -2017*

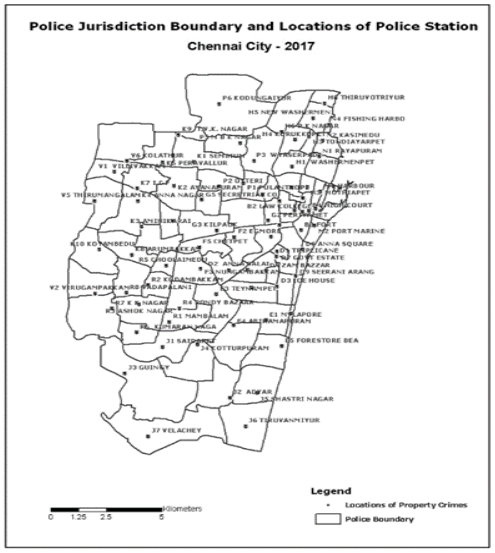
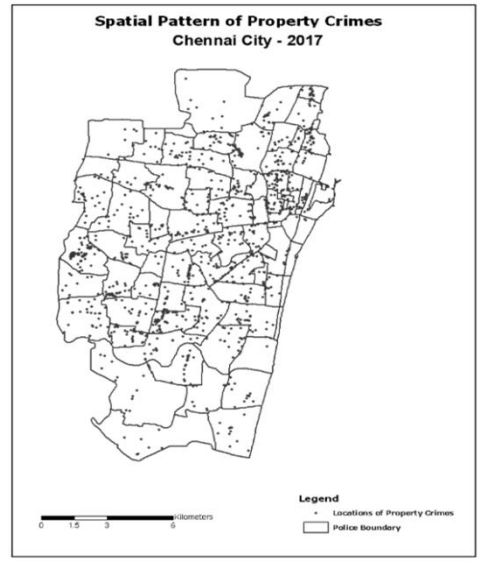



**Figure 2**

*Police Stations Location with Jurisdiction-* 2017




The commuting index has been calculated for each of the 70 police jurisdictions.

$$\text{Commuting Index: } \frac{\text{Total no.of Offenders living in the police station jurisdiction (B)}}{\text{Total no.of Offenders who live and commit a crime in the same police jurisdiction (C)}} \quad \text{(i)}$$

The higher value of the Commuting Index indicates that there are few opportunities in the area, so the offenders are required to travel out of their area. The commuting index has further been mapped (Figure 3).

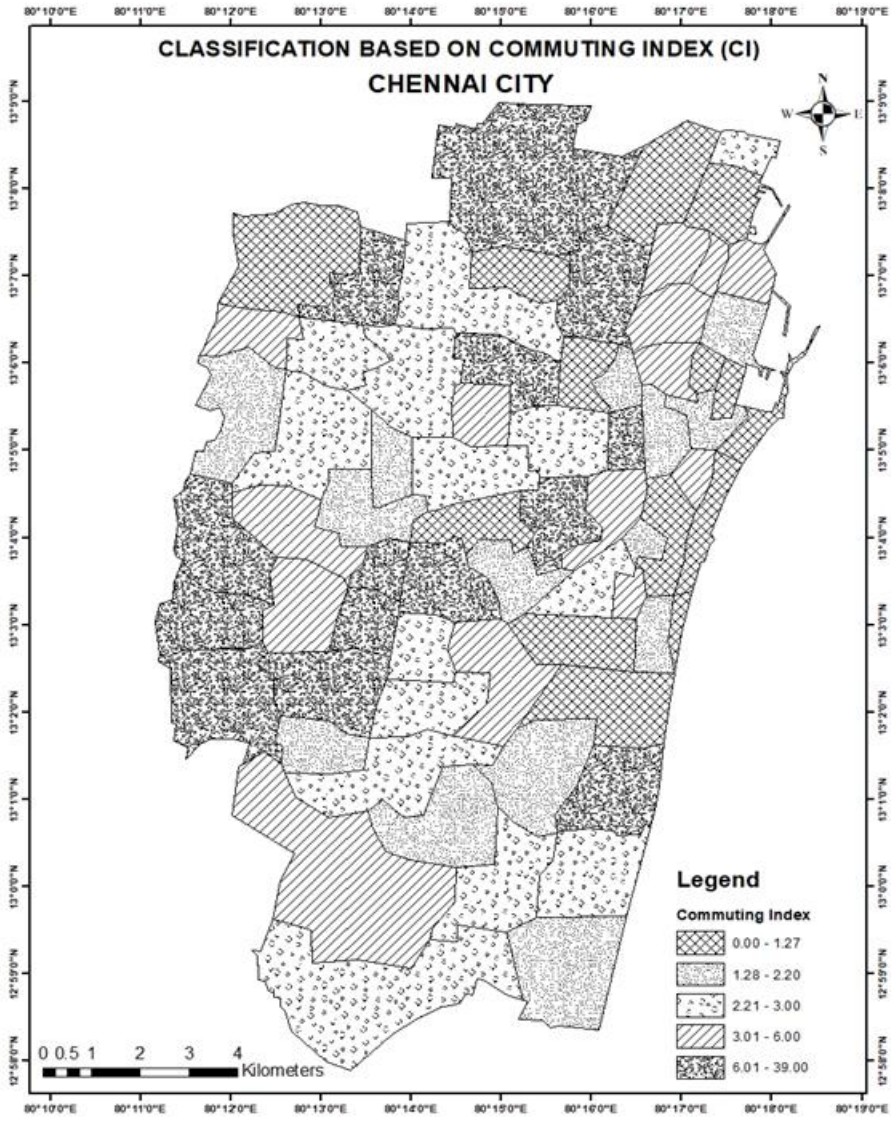
In areas such as P6 Kodungaiyur and P3 Vyasarpadi, the committing index is quite high, indicating a greater tendency to commit crime in new areas due to a lack of opportunities in their zone. Other zones, such as G7 Chetpet, E2 Royapettah, etc., are at the opposite end of the spectrum.

While tracking the mere outward movement of criminals alone would not provide a meaningful picture in terms of analysing usefulness, this has subsequently prompted the incorporation of an index known as the Relative Commuting Index (RCI) to help extract patterns. RCI is just an enhanced version of CI where the value obtained for a particular region is divided by the number of crimes committed there for which offenders are identified. The Commuting Index is based solely on the number of offenders who live and commit crimes in a given area. Commuting indexes only consider criminals who live and commit crimes in a particular area at a

given time. However, environmental factors that influence their choice of places to commit crimes can also be taken into account by looking at the number of Crime events within each jurisdiction. RCI faithfully incorporates this factor to map an offender's holistic commuting behaviour.

**Figure 3**

*Commuting Index (CI)*




In arriving at the RCI values for the different areas, the Police department was able to distinguish and link crime activities with alleged offenders. Therefore, a Relative Commuting Index is another commuting index variant expressed as a

proportion of total crimes committed in the area for which offenders are known. It is derived as below.

$$\text{Relative commuting Index: } \frac{\text{Commuting Index } (B/C)}{\text{Total crimes for which offenders are known } (A)} \quad \text{(ii)}$$

To explain the usefulness of RCI, a simple example is given here to help explain its importance in the current analysis.

For instance, we have two areas, A and B. The number of Criminals residing in A and B are 100, respectively. Of the total lot (100), only 50 operate inside A while 80 operate in B. From this, we arrive at the CI values of 2 and 1.25 for A and B, respectively. It is obvious from CI that criminals in Area B are reluctant to move out of their dwelling zone, while it is the other way around in Area A. Now that the CI is computed, RCI comes into play, which relies upon a Criminal's Modus Operandi. Since the number of native criminals who operate in A (50) tends to be much less than B (80), the number of crimes committed by them in A (say 25) would, by all means, be significantly lower when compared to B (say 50). By taking these values into account,

RCI for A = 2/25 = 0.08
RCI for B = 1.25/50 = 0.025

Having a lower RCI value for B further strengthens its chances of proving its environmental worthiness or scope for opportunity is far superior to A.

## Mapping and Analysis

As previously stated, the Relative Commuting Index (RCI) is the degree of commuting expressed as a ratio of the Commuting Index to the total number of crimes committed in the area. Choropleth maps were created using GIS software to demonstrate the spatial pattern of criminals travelling by treating police station jurisdictions as areal units. The lower index indicates that the area relies very little on external travelling because it is rich in environmental opportunities. Meanwhile, the higher score indicates fewer opportunities in the area, forcing criminals to travel outside.

When the pattern of occurrence of crimes is compared to the pattern of travelling of offenders, it becomes clear that locations with a higher degree of offenders' travelling have a lower crime rate. To put it another way, locations with a higher crime rate are thought to have more environmental opportunities, and as a result, the degree of travelling of offenders is low.

Table 1 contains the Number of Crimes for which Offenders are known (A), the Number of Offenders residing in the Area (B) and out of those who commit crimes locally (C). To corroborate the rationality behind narrowing their choices down to select areas and test them statistically, the Socioeconomic Development

(SED) indicator is considered. SED values represent how socially and economically sound an area is in percentage terms. A spatial and statistical approach is needed to prove the strong connection between SED and RCI.

**Table 1**

*Jurisdiction -wise Data*

| S.NO | AREA | A | B | C | CI | RCI | SED |
|---|---|---|---|---|---|---|---|
| 1 | H5 New Washermpet | 22 | 24 | 10 | 2.40 | 10.91 | 25.99 |
| 2 | N4 Fishing harbour | 7 | 1 | 1 | 1.00 | 14.29 | 25.01 |
| 3 | N2 Kasimedu | 8 | 19 | 6 | 3.17 | 39.58 | 28.94 |
| 4 | N3 Muthialpet | 13 | 6 | 1 | 6.00 | 46.15 | 30.94 |
| 5 | H3 Tondiarpet | 29 | 36 | 9 | 4.00 | 13.80 | 30.05 |
| 6 | P4 Basin Bridge | 5 | 1 | 1 | 1.00 | 20.00 | 27.75 |
| 7 | P6 Kodungaiyur | 24 | 69 | 10 | 6.90 | 28.75 | 30.86 |
| 8 | N1 Royapuram | 25 | 22 | 11 | 2.00 | 8.00 | 29.97 |
| 9 | P3 Vyasarpadi | 15 | 102 | 10 | 10.20 | 68.00 | 27.06 |
| 10 | H1 Washermanpet | 9 | 55 | 11 | 5.00 | 55.56 | 29.97 |
| 11 | K1 Sembium | 47 | 33 | 12 | 2.75 | 5.85 | 30.90 |
| 12 | V4 Rajamangalam | 1 | 0 | 0 | 0.00 | 0.00 | 31.76 |
| 13 | V5 Thirumangalam | 75 | 69 | 35 | 1.97 | 2.63 | 34.81 |
| 14 | K2 Ayanavaram | 70 | 24 | 10 | 2.40 | 3.43 | 31.43 |
| 15 | K4 Anna Nagar | 28 | 9 | 4 | 2.25 | 8.04 | 32.66 |
| 16 | K8 Arumbakkam | 33 | 23 | 6 | 3.83 | 11.62 | 32.32 |
| 17 | F5 Choolaimedu | 11 | 14 | 1 | 14.00 | 127.27 | 34.72 |
| 18 | G5 Secretariat Colony | 27 | 5 | 1 | 5.00 | 18.52 | 34.14 |
| 19 | C2 Elephant Gate | 31 | 23 | 15 | 1.53 | 4.95 | 27.42 |
| 20 | C3 Seven Wells | 44 | 35 | 7 | 5.00 | 11.36 | 29.32 |
| 21 | G7 Chetput | 1 | 0 | 0 | 0.00 | 0.00 | 36.79 |
| 22 | G1 Vepery | 39 | 20 | 9 | 2.22 | 5.70 | 32.49 |
| 23 | F2 Egmore | 27 | 9 | 1 | 9.00 | 33.33 | 34.09 |
| 24 | F4 Thousand lights | 55 | 33 | 22 | 1.50 | 2.73 | 36.79 |
| 25 | R2 Kodambakkam | 18 | 15 | 3 | 5.00 | 27.78 | 34.46 |
| 26 | R3 Ashok Nagar | 60 | 9 | 1 | 9.00 | 15.00 | 34.59 |
| 27 | R9 Valasarawakkam | 2 | 1 | 1 | 1.00 | 50.00 | 32.24 |
| 28 | F3 Nungambakkam | 41 | 8 | 1 | 8.00 | 19.51 | 34.94 |
| 29 | R4 Pondy Bazar | 49 | 3 | 1 | 3.00 | 6.12 | 38.35 |
| 30 | R1 Mambalam | 95 | 39 | 16 | 2.44 | 2.57 | 34.72 |
| 31 | E3 Teynampet | 26 | 25 | 7 | 3.57 | 13.74 | 33.12 |
| 32 | R6 Kumaran Nagar | 16 | 6 | 3 | 2.00 | 12.50 | 32.48 |
| 33 | J1 Saidapet | 27 | 40 | 15 | 2.67 | 9.88 | 29.45 |
| 34 | J4 Kotturpuram | 26 | 8 | 4 | 2.00 | 7.69 | 29.45 |
| 35 | E4 Abiramapuram | 52 | 18 | 12 | 1.50 | 2.88 | 34.23 |
| 36 | J7 Velacherry | 48 | 71 | 31 | 2.29 | 4.77 | 33.83 |
| 37 | J6 Thiruvanmiyur | 56 | 52 | 26 | 2.00 | 3.57 | 35.27 |
| 38 | J5 Sastri Nagar | 16 | 3 | 1 | 3.00 | 18.75 | 36.33 |
| 39 | E5 Pattinapakkam | 4 | 39 | 1 | 39.00 | 975.00 | 32.89 |
| 40 | D5 Marina | 9 | 1 | 1 | 1.00 | 11.11 | 35.29 |
| 41 | D3 Ice House | 19 | 22 | 10 | 2.20 | 11.58 | 28.29 |
| 42 | K10 Koyambedu | 69 | 9 | 1 | 9.00 | 13.04 | 32.36 |

| S.NO | AREA | A | B | C | CI | RCI | SED |
|---|---|---|---|---|---|---|---|
| 43 | R5 Virugambakkam | 21 | 39 | 1 | 39.00 | 185.11 | 32.36 |
| 44 | R7 KK Nagar | 11 | 8 | 1 | 8.00 | 72.73 | 30.72 |
| 45 | F1 Chindadiripet | 33 | 61 | 16 | 3.81 | 11.55 | 30.88 |
| 46 | D1 Triplicane | 66 | 44 | 22 | 2.00 | 3.03 | 39.56 |
| 47 | D7 Govt. Estate | 5 | 1 | 1 | 1.00 | 20.00 | 39.56 |
| 48 | D4 Zam Bazar | 11 | 6 | 2 | 3.00 | 27.27 | 33.48 |
| 49 | D5 Marina | 9 | 1 | 1 | 1.00 | 11.11 | 28.39 |
| 50 | B3 Fort | 3 | 4 | 1 | 4.00 | 1.33 | 32.24 |
| 51 | B5 Harbour | 1 | 0 | 0 | 0.00 | 0.00 | 30.18 |
| 52 | D6 Anna square | 8 | 1 | 1 | 1.00 | 12.50 | 30.63 |
| 53 | B5 Harbour | 1 | 0 | 0 | 0.00 | 0.00 | 30.63 |
| 54 | B1 North Beach | 15 | 8 | 7 | 1.14 | 7.62 | 30.63 |
| 55 | K6 T.P. Chatram | 24 | 12 | 9 | 1.33 | 5.56 | 31.98 |
| 56 | G2 Periamedu | 24 | 8 | 1 | 8.00 | 33.33 | 28.07 |
| 57 | C1 Flower Bazar | 44 | 22 | 16 | 1.38 | 3.13 | 25.78 |
| 58 | B2 Explanade | 20 | 9 | 7 | 1.29 | 6.43 | 32.24 |
| 59 | V1 Villiwakkam | 46 | 75 | 24 | 3.13 | 6.79 | 32.40 |
| 60 | K7 ICF | 14 | 3 | 1 | 3.00 | 21.43 | 30.69 |
| 61 | P1 Pullianthope | 21 | 83 | 7 | 11.86 | 56.46 | 30.05 |
| 62 | C5 Kothawal chavadi | 24 | 1 | 1 | 1.00 | 4.17 | 29.18 |
| 63 | E2 Royapettah | 45 | 19 | 15 | 1.27 | 2.81 | 36.50 |
| 64 | E1 Mylapore | 37 | 37 | 12 | 3.08 | 8.33 | 31.73 |
| 65 | J2 Adyar | 43 | 29 | 11 | 2.64 | 6.13 | 36.69 |
| 66 | P5 MKB Nagar | 16 | 1 | 1 | 1.00 | 6.25 | 28.88 |
| 67 | J3 Guindy | 22 | 82 | 14 | 5.86 | 26.62 | 29.19 |
| 68 | K3 Aminjikarai | 132 | 47 | 36 | 1.31 | 0.99 | 34.18 |
| 69 | K5 Peravalur | 15 | 19 | 2 | 9.50 | 63.33 | 33.44 |
| 70 | G3 Kilpauk | 36 | 17 | 7 | 2.43 | 6.75 | 35.31 |

With some notable exceptions, Table 1 and Figure 3 show a positive and negative correlation between CI, RCI, SED, and RCI, respectively. RCI and CI tend to be directly proportional, with the key difference being a criminal's pure willingness to explore (CI) and the environmental opportunities that influence his decision (RCI). It can be seen from Figure 3 that regions with low levels of development have higher levels of commuting and vice versa. Noteworthy exceptions like E5 Pattinapakkam and F5 Choolaimedu are the causal effects of factors like frequent Police patrolling and the presence of VIP residences.

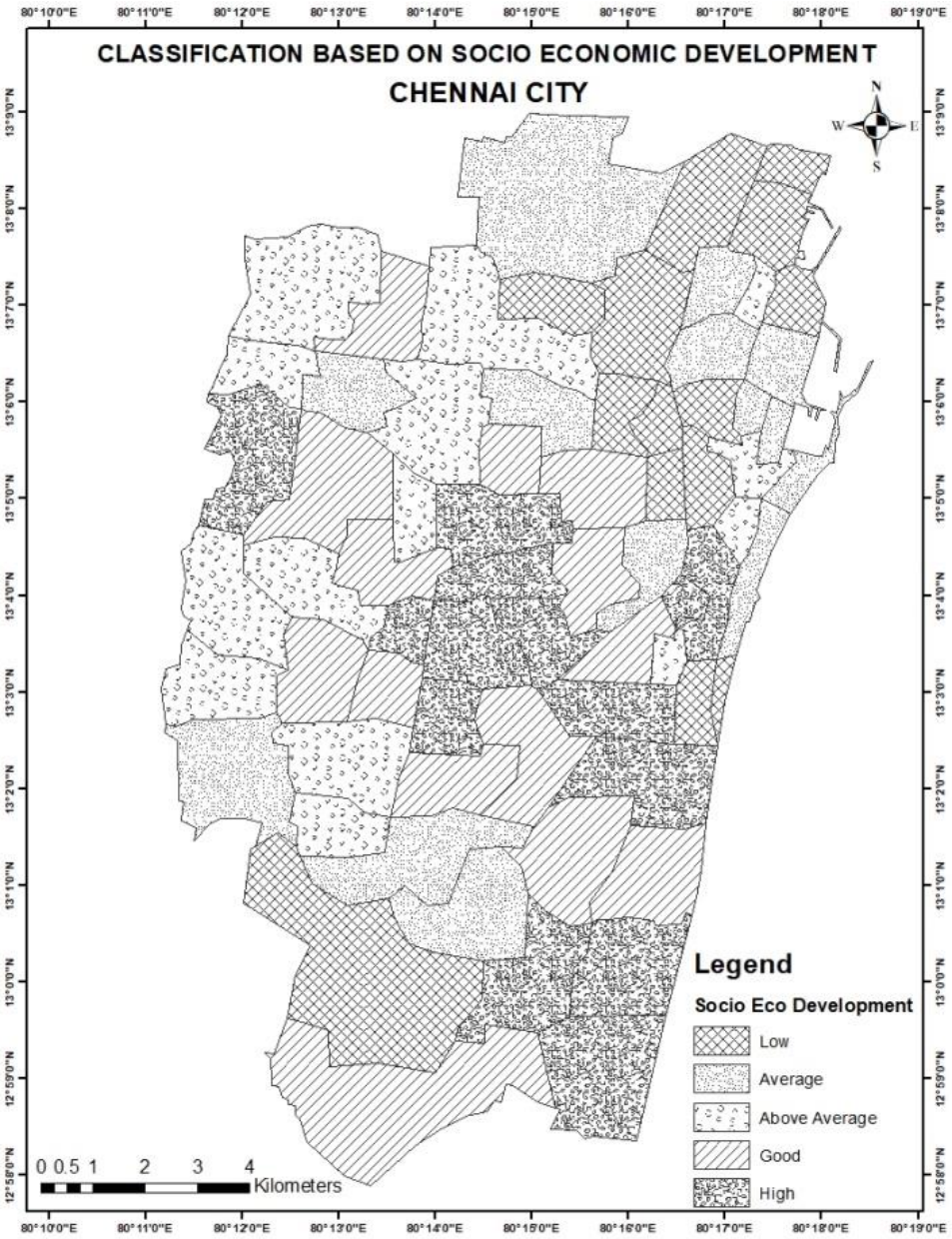
Figure 4 shows that in areas such as Aminjikarai (K3), Pondy Bazaar (R4), and Anna Salai (D2) in Central Chennai, Thirumangalam (V5) and Ayanavaram (K2) in the West, Triplicane (D1) in the East, Harbour (B5) and Flower Bazaar (C1) in the North, and Adyar (J2) in the South, criminals have a low preference for travelling. Because of the lower level of commuting of offenders in these locations, most criminals likely commit crimes in their neighbourhood.

It is observed that these areas, especially Pondy Bazaar and Anna Salai in Central Chennai and Flower Bazaar in North Chennai, are essentially characterised by commercial and service functions—the other areas, namely. Aminjikarai in

Central Chennai, Thirumangalam in the West and Adyar in the South are mainly the high-income residential areas. These areas also provide a great environmental opportunity for offenders. A relatively lower percentage of travelling is also found in the peripheral parts of Southern Chennai, characterised by industrial and high-income functions.

**Figure 4**

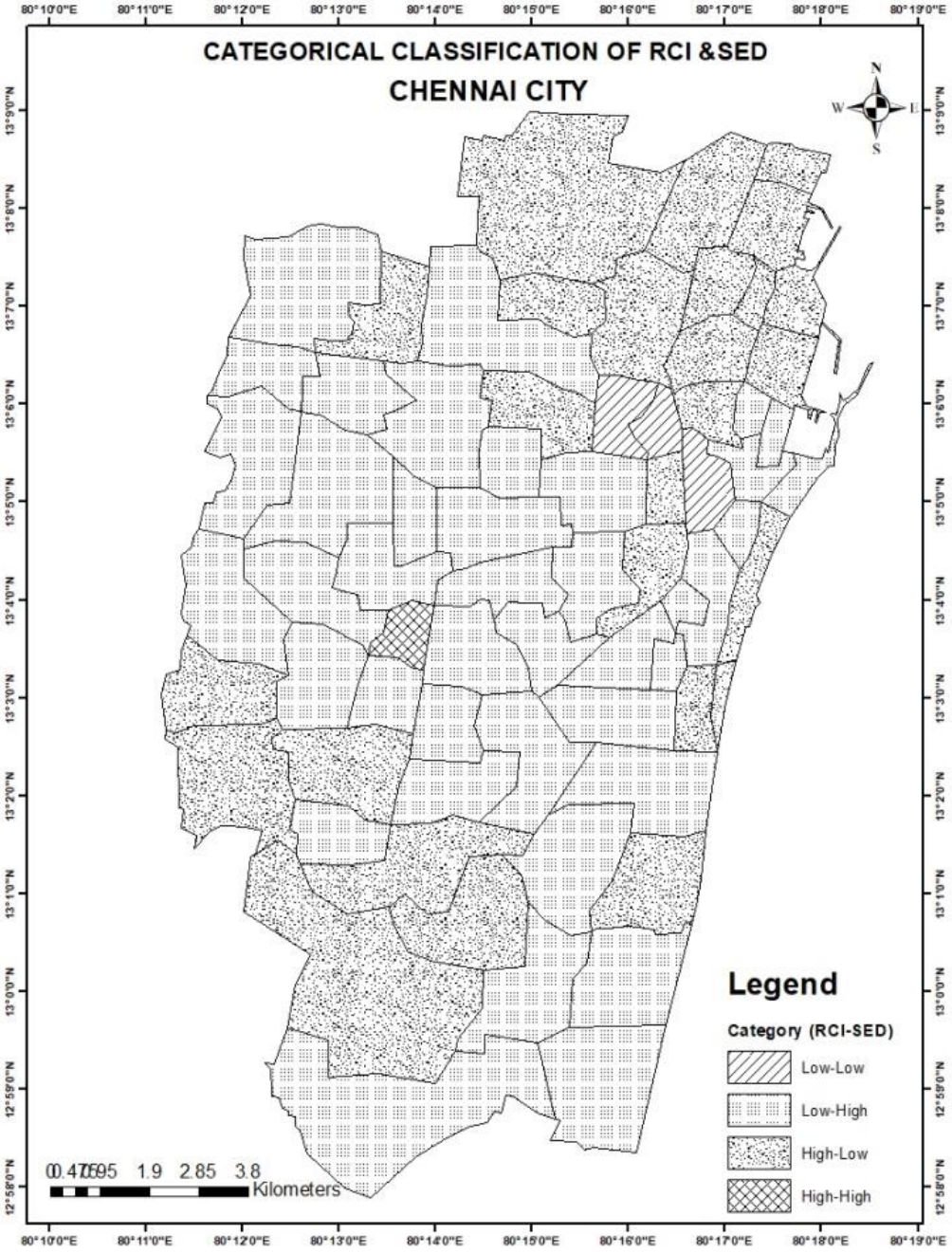
*Comparing SED With Commuting Preference*



The concentration of a high degree of travelling (Hotspot-like feature) is found distinctly in the North and North East Chennai.

**Figure 5**

*Relative Commuting Index (RCI)*



Furthermore, most offenders prefer their home (areas where they reside) to distant counterparts, as seen in Figure 4, with some noticeable exceptions in Chennai's northern parts. In contrast to the previous observation, the latter demonstrates a lack of opportunities due to low living conditions. Figure 5 indicates the relative commuting index.

**Table 2**

*RCI-SED Pair Values and Police Divisions*

| RCI/SED | Police Divisions |
|---|---|
| Low-Low | C2 Elephant Gate, C1 Flower Bazar, C5 Kothawal chavadi |
| Low-High | K1 Sembium, V4 Rajamangalam, V5 Thirumangalam, K2 Ayanavaram, K4 Anna Nagar, K8 Arumbakkam, G5 Secretariat Colony, G7 Chetput, G1 Vepery, F2 Egmore, F4 Thousand lights, R2 Kodambakkam, R3 Ashok Nagar, F3 Nungambakkam, R4 Pondy Bazar, R1 Mambalam, E3 Teynampet, R6 Kumaran Nagar, E4 Abiramapuram, J7 Velachery, J6 Thiruvanmiyur, J5 Sastri Nagar, D5 Marina, K10 Koyambedu, D1 Triplicane, D7 Govt. Estate, D4 Zam Bazar, B3 Fort, B5 Harbour, B1 North Beach, K6 T.P. Chatram, B2 Esplanade, V1 Villivakkam, K7 ICF, E2 Royapettah, E1 Mylapore, J2 Adyar, K3 Aminjikarai, G3 Kilpauk |
| High-Low | H5 New Washermanpet, N4 Fishing harbour, N2 Kasimedu, N3 Muthialpet, H3 Tondiarpet, P4 Basin Bridge, P6 Kodungaiyur, N1 Royapuram, P3 Vyasarpadi, H1 Washermanpet, C3 Seven Wells, R9 Valasarawakkam, J1 Saidapet, J4 Kotturpuram, E5 Pattinapakkam, D3 Ice House, R5 Virugambakkam, R7 KK Nagar, F1 Chindadiripet, D2 Marina, D6 Anna square, G2 Periamedu, P1 Pullianthope, P5 MKB Nagar, J3 Guindy, K5 Peravalur |
| High-High | F5 Choolaimedu |

Table 2 denotes the categorical classification of various Police Jurisdiction limits according to four combinations of RCI-SED Pair values. Since the very purpose of this paper is to cull out the negative correlation between RCI and SED parameters, this table is a testimony for the same, as 40 of the limits fall under the Low-High category, 26 under High-Low, three under Low-Low and one under High-High.

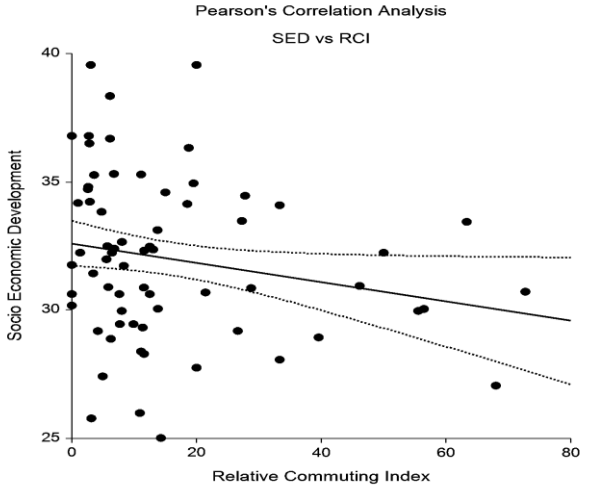
A Low-High combination indicates that the offenders in an area of interest are reticent to move out of their places to commit crimes. On the contrary, a High-Low Combination expresses their desire to move out due to the prevalence of low economic opportunities to commit crimes in their residing places.

Low- and High-High combinations refute our core hypothesis but can be considered outliers due to their minuscule number of 4.

Pearson's correlation coefficient analysis is performed between the Development indicator (SED) and the RCI using NCSS Statistical software, and its statistical significance is tested.

**Figure 6**

*Correlation Between SED and RCI*




According to the results (Figure 6), there is an obvious decline in the regression line, bounded by 10% Confidence Intervals on both sides, showing a clear negative correlation between the two. A few notable outliers (such as Pattinapakkam (E5)) were ignored to arrive at a factual conclusion.

Further, Null($H_o$) and Alternative hypothesis ($H_a$) were formulated, and the data was tested for significance at Probability value($\alpha$=0.1) where $H_o$ denotes no significant correlation, i.e. the variables are random, and $H_a$ disapproves it.

**Table 3**

*Pearson Correlation Test Section*

Ho: $\rho = 0$

| Alternative Hypothesis | Pearson Correlation | Count | df | T - Value | P-Value | Reject Ho at $\alpha = 0.1$? |
|---|---|---|---|---|---|---|
| $\rho \neq 0$ | -0.2051 | 67 | 65 | 1.6897 | 0.0959 | Yes |

Source: NCSS Statistical Software

Since the obtained P- Value (0.0959) is less than the assumed probability value ($\alpha$=0.1), $H_o$ is rejected, and a significant correlation between SED and RCI is further reestablished (Table 3).

Locations with low environmental opportunities have a relatively high degree of travelling, which can be vital in monitoring the movements of recorded suspects in high-valued RCI areas while beefing up the security levels in high-valued RCI counterparts.

## Conclusion

Criminals travelling are less common in commercial and high-income residential regions due to increased environmental opportunities. However, it is also vital to highlight that some exceptions are related to evident causative causes. In this way, the study helps us understand the relationship between offenders' travel patterns and the areas' characteristics. Moreover, from a Geographers perspective, apart from just a mere spatial portrayal of events, this study has employed Statistical techniques to ascertain the factors of influence as it is essential to cull out the root cause, say, for instance, analysing the push and pull factors that prompt these malicious occurrences. Push factors are the ones that force a person to commit crimes in the likes of poverty and unemployment, which can be noticeably recognised in areas of low socio-economic development, especially in northern parts of the city, and Pull factors express the magnetic pull some of the areas in central parts of the city have on gullible people to commit offences due to socio-economic disparities and increasing capitalistic environment. Therefore, mitigating crime requires tough laws and punishments, increased attention to Push and Pull factors, and allocating resources that address equity in regional development and living standards.

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# Population and Land Use Characteristics of Rural-Urban Fringe Around Raipur City, Chhattisgarh

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**Abstract:** Uncontrolled urbanisation is a prominent phenomenon in developed and developing countries. The area most affected by fast and unplanned urban growth is the surrounding cities' fringe area. The study was conducted to determine the status of the Raipur fringe area and its regional importance through its locational aspects. Relevant data were collected from the district census handbooks of different years. The rural-urban fringe was divided into five zones through a buffer of 4 km distance to analyse population characteristics and land use. Statistically, a significant correlation was found between distance and different parameters. The result shows the dynamic nature of the rural-urban fringe, which projects a probable aspect for more rapid urban growth in the near future, which is necessary to monitor.

***Keywords*:** fringe, demography, correlation, land use, buffer

India is fast urbanising among developed and developing countries. Because of its sheer population numbers, it contains a massive urban population. Now, the fact is that with the growth of urban population locations, the urban area also has to increase to counter the growth. As the urban boundary grows in the near future, the villages in this fringe area will be included in the rapidly growing city. Here, the question arises: What is fringe, and why is it important?

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The term "urban fringe" was first introduced by T. L. Smith in 1937 to describe the built-up area outside the city limits (Ahmed et al., 2014), though the word “rurban" used by Galpin in 1915 was synonymous with the fringe (Lal, 1987). Wehrwein (1942) first defined the rural-urban fringe as a transitional area between well-organised urban and agricultural land use. Prayor (1968-69) divided the fringe into urban and rural fringes based on land use composition. In other words, the fringe is a bridge between rural areas and urban centres on the other (Sinha, 1980).

The fringe area is very important because, in the near future, this area will become part of urban settlement. However, plans have not been adopted for this area as it is outside the boundaries of urban settlements. As a result, unplanned urban growth, overpopulation, land acquisition, pollution, and land use have emerged as problems. Hence, there is a special need to know the variable features of this particular region. The present study attempts to investigate the complex interplay between land use changes and population dynamics in the fringe area of an Indian city and understand the implications for sustainable urban development and planning. Since its recognition as the capital city on November 1 2000, Raipur City has gone through a significant increase in its magnitude and pace of urbanisation. Regarding its significant geographical location and dynamic nature, the Raipur fringe has emerged as ideal for studying the speciality of fringe regions. Hence, in the present study, an attempt has been made to explore the prominent features of the fringe area of Raipur city in terms of space and time.

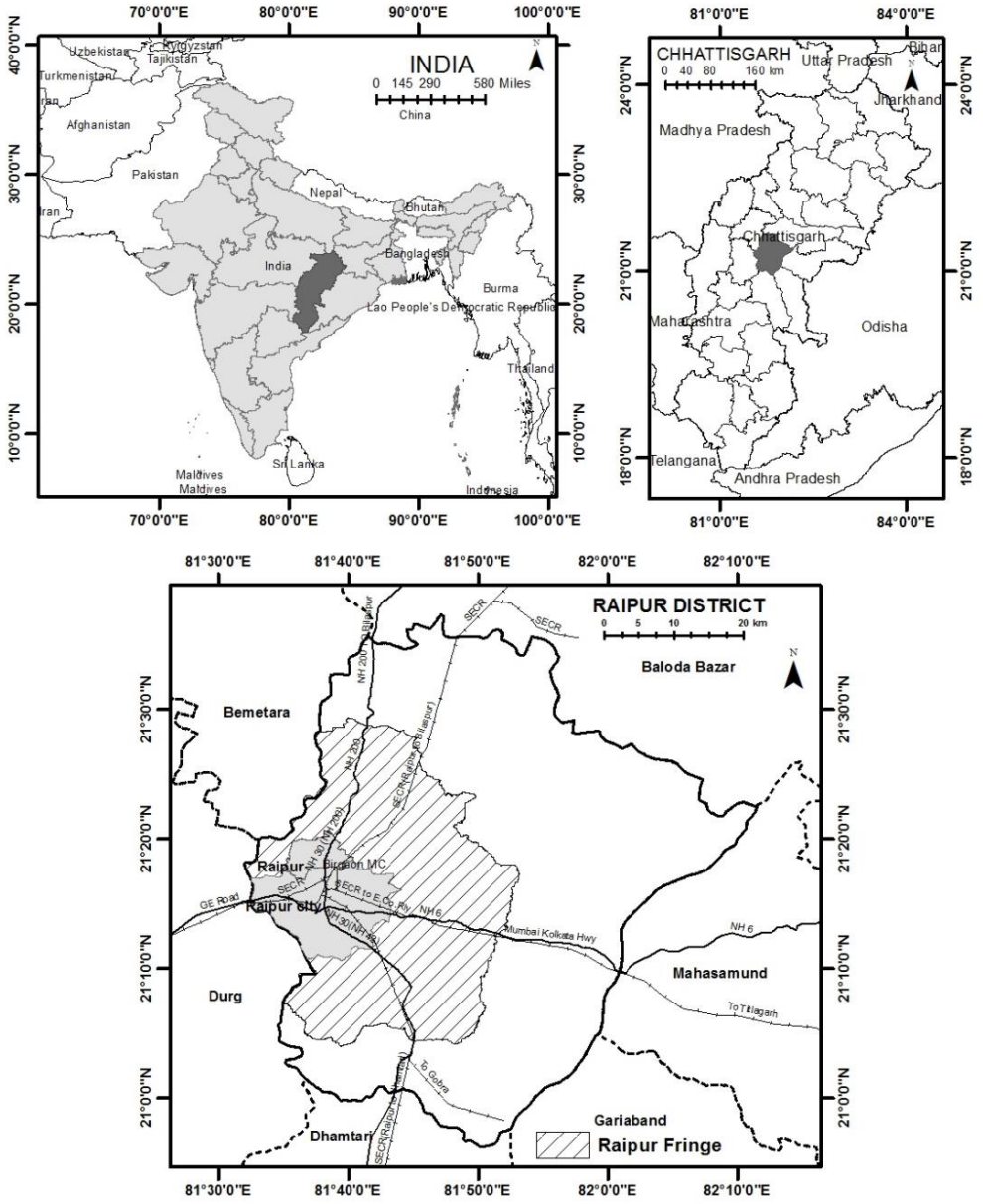
## Study Area

The capital city of Raipur is located at approximately the centre of Chhattisgarh and belongs to the Mahanadi Plain. The city is extended from 21°10'35.82″ N to 21°20'40.276″ N and 81°32'29.076″E to 81°44'8.877″E. The latitudinal extension of the fringe area is 21°3'55″N to 21°29'24″N, and the longitudinal extension is 81°31'57″E to 81°53″13″E. A total area of 1078.5 sq km was covered by Raipur City and its fringe (as demarcated by the author). Mahanadi River and Kharun River flow on the eastern and western sides of the study area. The study area connects Nagpur, Howrah, and Rourkela through rail routes and several National highways.

## Objectives of the Study

Examine the changing population dynamics and land use characteristics that reflect the significance of Raipur, a state capital city and its fringe area. It also configures the advantages of the Raipur fringe area from its locational point of view.

**Figure 1**
*Location Map of the Study Area*

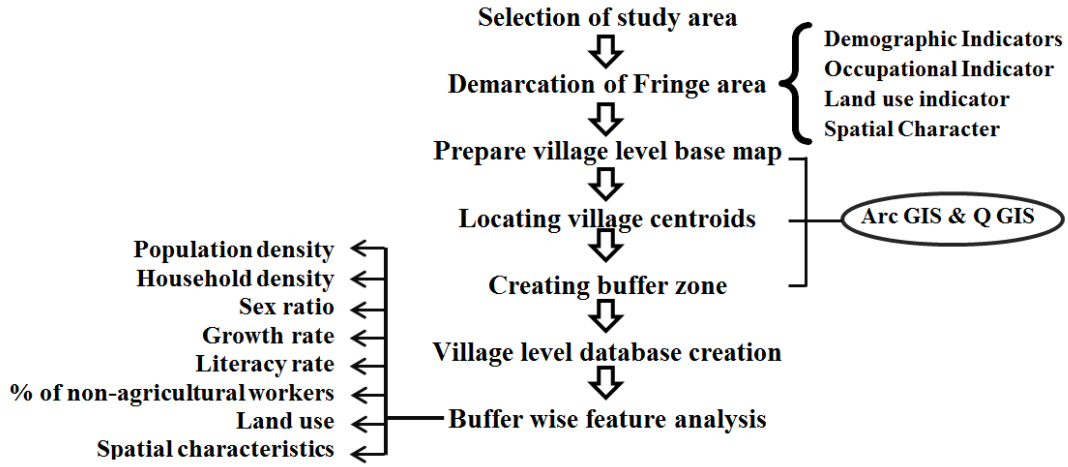



## Database and Methodology

This study's village-level census data was taken from the District Census Handbook from 1991 to 2011. The fringe area of Raipur city was demarcated through various indicators. Demographic, occupational structure and land use have been taken as indicators. In the next step, the village-level base map was prepared with the help of Arc GIS software. In the next stage, the fringe region is divided into several

rings by the buffer method with ArcGIS. It has been seen that the minimum and maximum distance of the fringe area from the city centre is six km and 26 km, respectively. So now, the extension of the fringe area in different directions is 20 km. Primary observations during the pilot survey showed that changes in features in different directions are less obvious at short distances (within one or two km). Therefore, considering the stated reason and equal distance, the entire region has been divided into five zones at an interval of four km. Along with this, the help of village centroids has been taken to comprise the villages within the entire fringe area in various zones. Population density, household density, population growth, sex ratio, and literacy rate have been analysed as demographic features. The occupational structure has been explained in terms of non-agricultural main workers.

*Steps Followed for the Study*




## Results and Discussion

After demarcation, it was found that a total of 153 villages surrounding Raipur City have come under the fringe region of Raipur City. Two census towns and one statutory town are also associated with the Raipur fringe (Fig. 2).

In the next step, five buffer zones were drawn at 4-kilometre intervals from the city centre after determining the village centroid point through Arc GIS (Fig. 3). A total of 18 villages fall within zone one (from the city centre to 10 km). Subsequently, 32, 37, 36 and 30 villages have been fallen under the 2nd zone (10-14km), 3rd zone (14-18km), 4th zone (18-22km) and 5th zone (22-26km).

**Figure 2**

*Detail Map of Raipur Fringe Area With Buffer Zone*

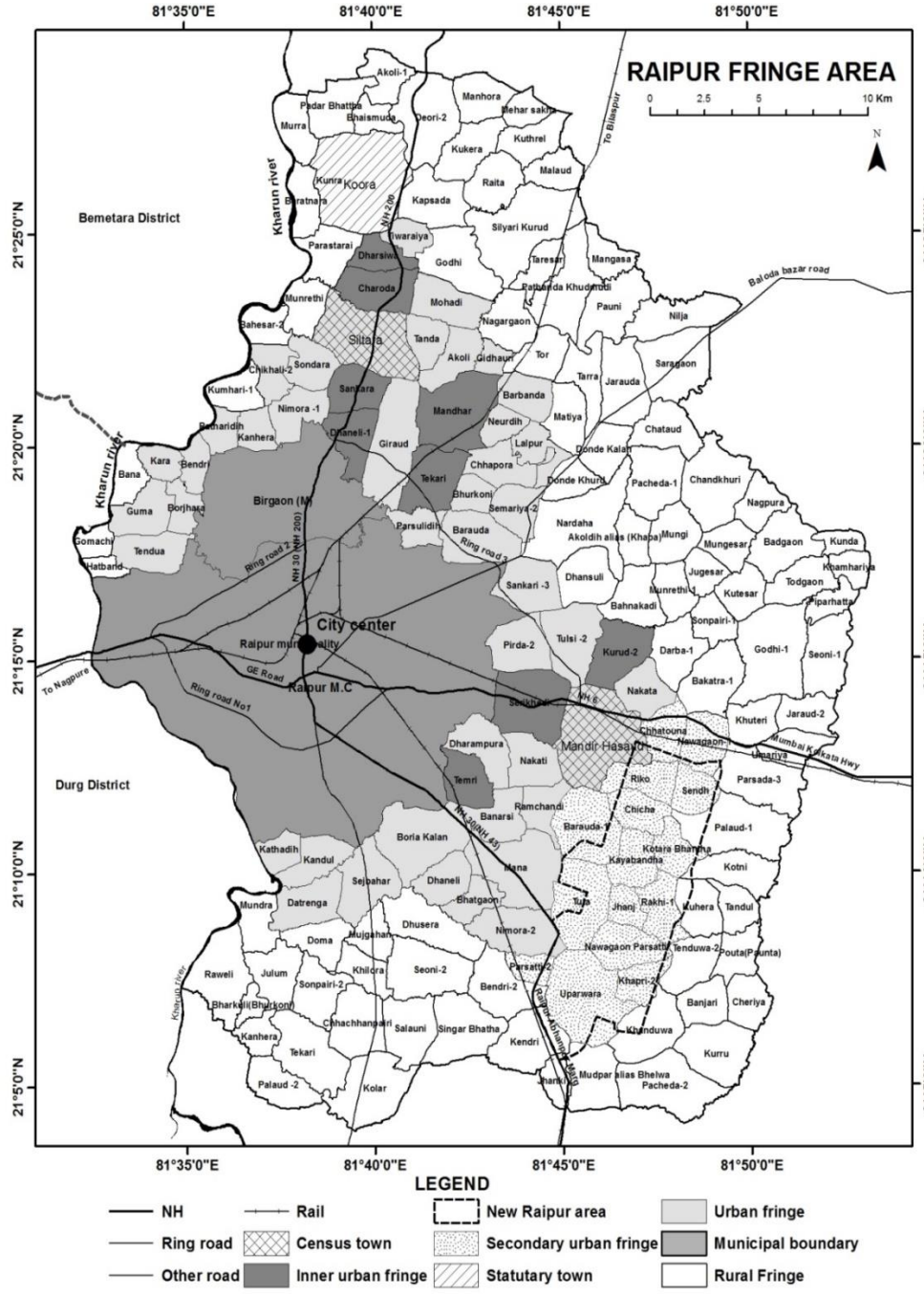
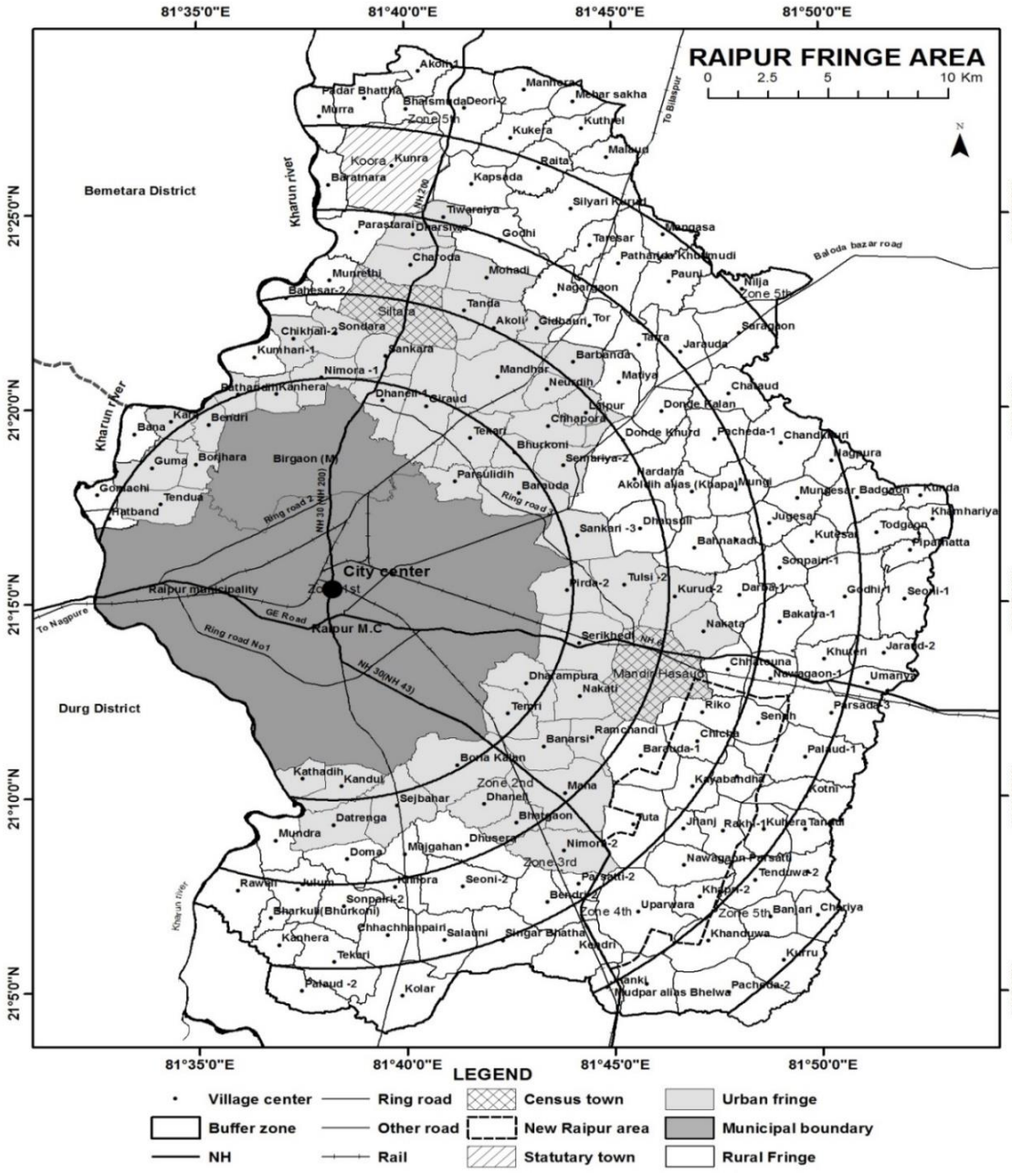


**Figure 3**

*Village Centroids and Buffer Zone of Raipur Fringe*




The characteristics of the Raipur fringe region are discussed in the ensuing sections.

## Demographic Features

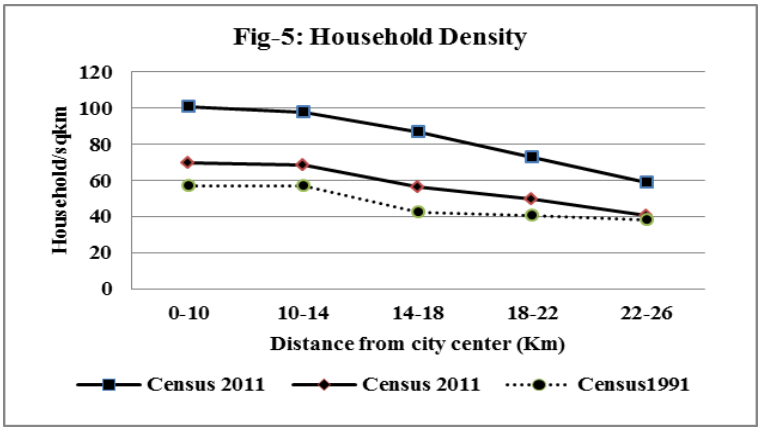
In this study, population density, household density, sex ratio, growth rate, and effective literacy rate have been analysed regarding demographic conditions.

### *Density of Population*

According to the Census in 2011, the rural population density of Raipur district was 217 persons/ sq km. Analysis shows that the density of the first ring, i.e., 0-10 km, is highest at 520 persons/ sq km (Census, 2011), much higher than the rural proportion of the whole district. Declining population densities were found in subsequent zones (Fig. 4). According to the 2011 census, the population density of the first three zones is 520 (zone 1), 497 (zone 2) and 427 (zone 3), respectively, which is higher than the minimum census criteria of urban settlement. The lowest population density was 287 persons/ sq km, found in zone no five, with a distance of 22-26 km from the city centre. A similar trend has been observed by analysing the data of census 2001 and census 1991. In the last two decades, the population density of the first two zones has increased by about 200 persons per square kilometre, which shows the rapid change in the population of the first two zones.

### *Household Density*

Due to the facilities and modern life in the urban areas, the migration rate from the village to the city is usually much higher. The effect of this character can be noticed in the fringe region. According to the 2011 census, the housing density in rural areas of the Raipur district is 47 households per square kilometre (calculated by the author from census data). An analysis of the 2011 census shows that the housing density in each zone is higher than the rural housing density. In the first zone, i.e., between 0-10 km, the highest housing density is 102 households per sq km. This rate of household density is generally seen to be declining in the later zones (Fig. 5). The household density is 98 households/sq km in Zone 2nd, 86 households/sq km in Zone 3rd, 72 households/sq km in Zone 4th, and 59 households/sq km in Zone 5th, respectively. However, one thing is that there is not much difference between the first and the second zones in terms of housing density. This trend is similar in the 2001 census and the 1991 census. According to the 2001 census, the household density in the first and second zones is 70 and 68 per sq km, respectively, and according to the 1991 census, it is 56 and 57 per square kilometre. In both census decades (2001, 1991), household density was lowest in the 5th zone at 41 and 38 households/ sq km. The household density of the 1st and second zones increased almost twice from 1991 to 2011.




### *Sex Ratio*

The sex ratio is generally higher in rural areas than in urban areas. Due to the greater migration of the male working population from rural to urban areas for higher livelihood and employment opportunities, the sex ratio is generally lower in urban areas than in rural areas. According to the 2011 census, in Raipur fringe, the sex ratio is the lowest in the first and second zones. The sex ratio is 970 females/1000 males in Zone 1(within 10km)and 961 females/1000 males in Zone 2(10-14km). The sex ratio in subsequent zones is steadily increasing. In the third, fourth and fifth zones, the sex ratio is 972,985 and 999 females per 1000 males, respectively. Looking at the 1991 and 2001 censuses, the sex ratio is lower in the first zone and higher in the latter.

### *Growth of Population*

In Raipur district, the decadal variation in urban population is 61.6% from 2001 to 2011. Decadal variation in Raipur tehsil has also been very high, showing 53 % in urban areas and 18.8% in rural areas. In the case of fringe areas, the growth rate is generally higher near the city. However, in the Raipur fringe area, the population growth rate was highest in the 2$^{nd}$ zone in the previous two census decades (from 1991 to 2001 and 2001 to 2011). The growth rate in 1$^{st}$ zone is almost similar in 2001(22.90%) and 2011(23.08%). However, in the 2$^{nd}$ zone, the growth rate was highest in the 2001(28.41%) and 2011(35.18%) censuses. That might be due to the high price of land proximity to the municipal boundary. The growth rate has declined in the latter zone, but the lowest growth rate in the 3rd zone, 13.88 %, was in the 2011 census. However, in the case of the 2001 census, the growth rate indicates a sharp decline after the 2$^{nd}$ zone (14-18km from the city centre).

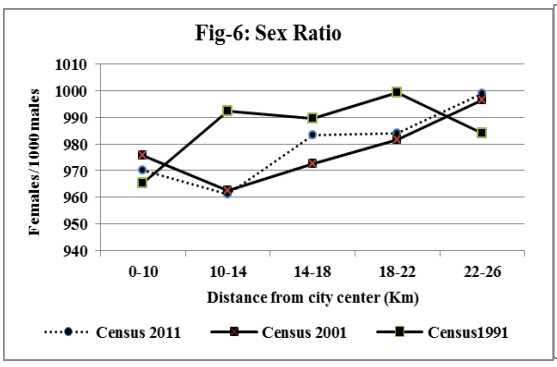
### *Literacy Rate*

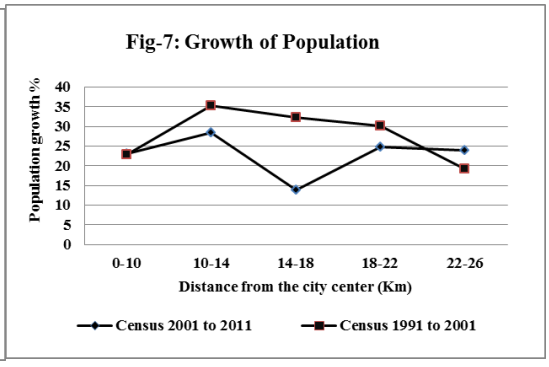
The literacy rate of the Raipur fringe region shows both rural and urban character. The impact of urbanisation is greater in the vicinity of the city, so the literacy rate (76.18%) is highest in the first zone, i.e., in villages within 0-10 km.

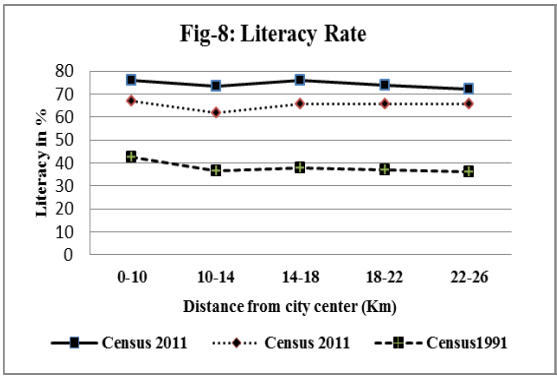
According to the 2011 census, the first zone's literacy rate was 5.7% higher than the rural literacy rate of the Raipur district. The lowest literacy rate of the Raipur fringe region has been observed in the last zone (22-26km), which is 72.14%, which is also 1.16% higher than the district's rural literacy rate. The last zone is the farthest from the city, so the literacy rate is the lowest. Also, the literacy rate has been declining with increasing distance from the city; only the literacy rate in the third circle (75.85%) is almost equal to that of the first circle.

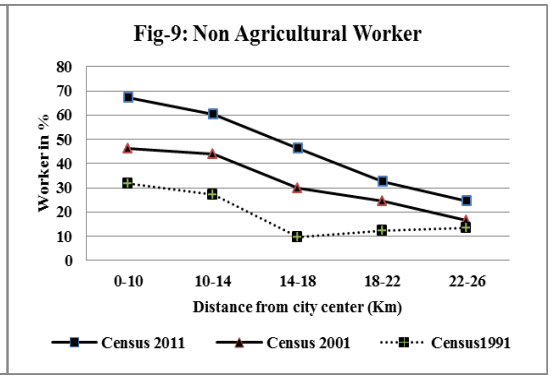
### *Occupational Structure*

The share of non-agricultural workers of the main workers of the Raipur fringe region has been taken for this analysis. After the zone-wise analysis, it is seen that the proportion of non-agricultural workers is highest in the first zone, i.e., villages within 0-10 km. In the first round, 67.07% of the main workers are associated with non-agriculture activity, the highest in the fringe region. In the last zone, i.e., 22-26 km, this ratio was found to be 24.32%, the lowest in the fringe region. This percentage has gradually decreased from the first zone to the next zone (Fig. 9). In the second, third and fourth zones, 60.22%, 46.25%, and 35.51% of people are involved in non-agricultural activities, respectively. According to the censuses of other decades, the same pattern has been observed.



## Land Use

Land use in Raipur fringe area has been analysed according to different zones. According to the village-level land use data in the 2011 district census handbook, Raipur district (village directory), this is. In the 2011 census, village-level land use was based on a nine-fold classification. However, no significant land use was found in the Raipur fringe area; the major land use types of the Raipur fringe have been analysed below.

### *Forest Land*

Forest and tree coverage is very common in rural areas (censusindia.gov.in). The forests were not particularly observed in the Raipur fringe area. Only in the last two zones, i.e., Zone 4 (18-22 km) and Zone 5th (22-26 km), 0.78% and 0.96% forest cover have been found.

### *The Area Under Non-Agricultural Use*

Analysis shows this land use is highest in the two belts near the city. In the first zone (0 to 10 kilometres), 10.66 % and in the second zone (10 to 14 kilometres), 15.30 % of the land was under this land use (Fig-10). The use of this type of land has been gradually reduced in the subsequent zones, i.e. 9.30 % and 8.69 % have been found in the third and fourth zones, respectively. However, in the last ring, the amount of this type of land was found to be 10.09%, which shows the opposite character.

### *Barren and Unculturable Land*

Not much of this land was found in the Raipur fringe area. Only 1.39 % and 1.42 % were observed in the third and fourth zones. The amount of this type of land in other zones is negligible.

### *Permanent Pastures and Other Grazing Land*

This type of land covers a good portion of all the five zones in the fringe area. The amount of this type of land is lowest in the first and second zones. This type of land occupies 11.85% (1036.8 hectares) and 10.29% (1674.64 hectares) of the total land in the first and second zones, respectively (calculated by the author). The proportion of permanent posture and other grazing land was increased in later zones. In the second, third and fourth zones, this type of land has been found at 13.05%, 14.95% and 12.65%, respectively.

### *Land under Miscellaneous Tree Crops*

This type of land was also negligible, with only 0.76% in the third zone.

### *Culturable Waste Land*

The amount of this type of land is most visible (11.29%) in the belt near the city. In subsequent zones, the amount of this type of land is less, respectively. As the distance from the city increases, the amount of this type of land decreases. In the second, third, fourth and fifth zones, the amount of such land was found to be 10.16%, 5.77%, 3.97%, and 8.89 %, respectively.

### *Fallow Lands Other Than Current Fallow*

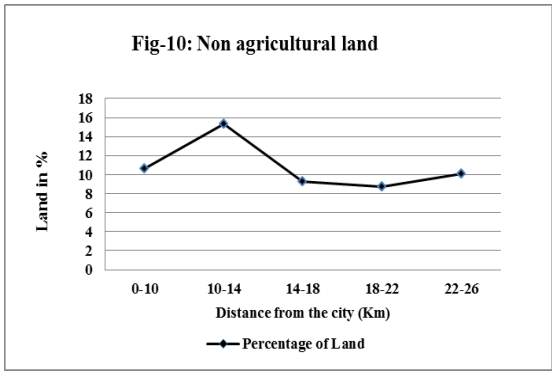
Such type of land is considered as fallow land other than current fallow. This type of land is most visible in the zone near the city. The amount of such land in the first zone is 860.06 hectares, 9.83% of the total (8748.21 hectares) land in that zone (Fig-13). Although this type of land is more in the second zone (1149.46 hectares out of 16267.8 hectares) than the first zone, the amount is less in percentage (7.07%). Subsequent zones have seen a decrease in the amount of this type of land. Only 5.45% of this land was found in the last zone.

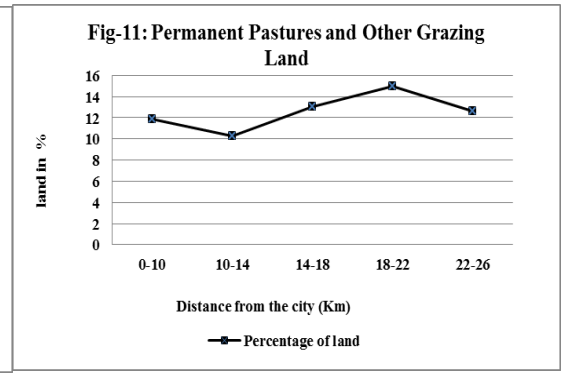
### *Current Fallow*

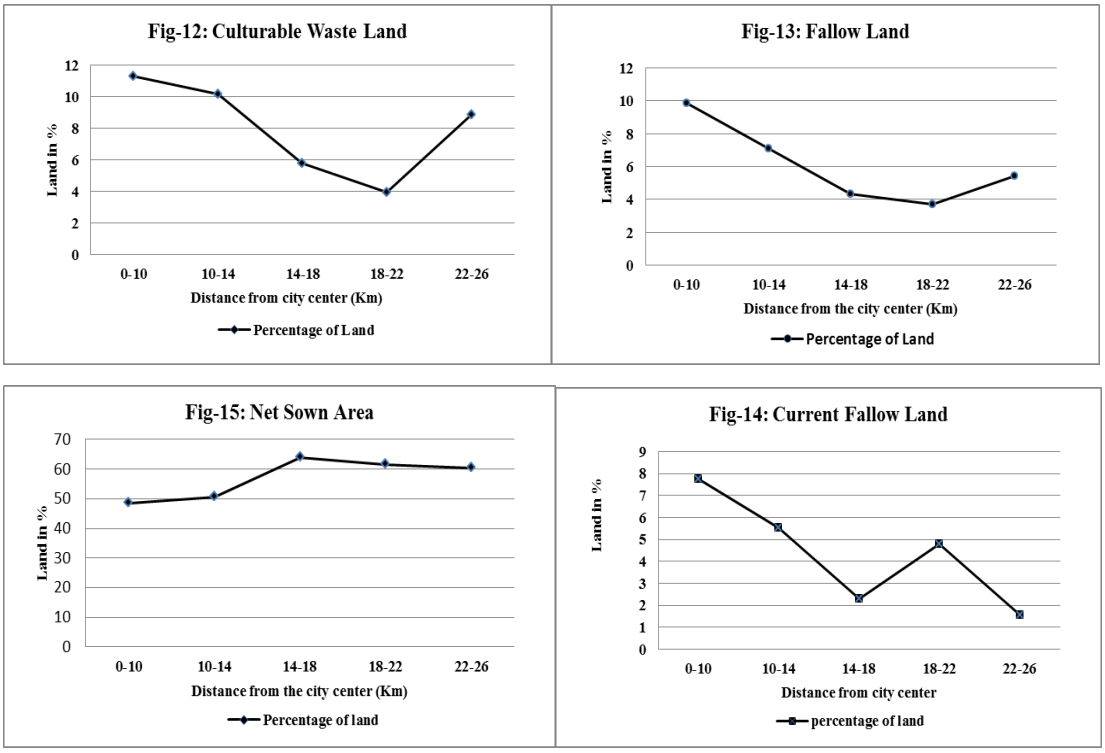
The same trend has been found in using this type of land as in the previous two types of land use. The highest percentage of current fallow land has been found in the first zone within 0 to 10 km, which is 678.15 hectares (7.75% of the total land of 1st zone). This type of land is found to be lowest in the last zone (22-26 kilometres), amounting to 1.55% of the total (222.44 hectares) land in that zone. As the distance from the city increased, the amount of this type of land declined.

### *Net Sown area*

This type of land use has the opposite character from the three types of land use discussed earlier. This means that the use of this type of land is the lowest in percentage terms near the city and has increased with increasing distance. The amount of such land in the first zone is 4247.14 hectares, 48.55% per cent of the total land (8748.21 hectares). Although increased in subsequent zones, this type of land was found in the third zone. In the second, third and fourth zones, the amount of such land was found to be 50.50%, 63.88 %, 61.67% and 60.22%, respectively.






## Table 1

*Zone Wise Land Use Distribution of Raipur Fringe (District Census Handbook, 2011)*

| Land Use in Raipur Fringe Area(in Hectares), Census 2011 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance in km | Forest Area | The area under Non-Agricultural Uses | Barren & Un-cultivable Land Area | Permanent Pastures and Other Grazing Land Areas | Land Under Miscellaneous Tree Crops, etc. Area | Culturable Waste Land Area | Fallows Land other than Current Fallows | Current Fallows Area | Net Sown Area | total |
| 0-10 | 0 | 932.46 | 5.53 | 1036.8 | 0 | 988.07 | 860.06 | 678.15 | 4247.14 | 8748.21 |
| 10-14 | 0 | 2488.57 | 64.98 | 1674.64 | 124.42 | 1653.08 | 1149.46 | 896.94 | 8215.71 | 16267.8 |
| 14-18 | 0 | 2016.85 | 301.49 | 2828.77 | 0 | 1251.03 | 933.8 | 498.84 | 13850.03 | 21680.8 |
| 18-22 | 168.32 | 1864.63 | 304.73 | 3208.33 | 0 | 851.76 | 799.43 | 1027.56 | 13232.69 | 21457.5 |
| 22-26 | 137.09 | 1447.05 | 28.05 | 1815.56 | 0 | 1275.65 | 781.73 | 222.44 | 8640.58 | 14348.2 |
| total | 305.41 | 8749.56 | 704.78 | 10564.1 | 124.42 | 6019.59 | 4524.48 | 3323.93 | 48186.15 | 82502.4 |
| | Land use in percentage | | | | | | | | | |
| 0-10 | 0.00 | 10.66 | 0.06 | 11.85 | 0.00 | 11.29 | 9.83 | 7.75 | 48.55 | 100.00 |
| 10-14 | 0.00 | 15.30 | 0.40 | 10.29 | 0.76 | 10.16 | 7.07 | 5.51 | 50.50 | 100.00 |
| 14-18 | 0.00 | 9.30 | 1.39 | 13.05 | 0.00 | 5.77 | 4.31 | 2.30 | 63.88 | 100.00 |
| 18-22 | 0.78 | 8.69 | 1.42 | 14.95 | 0.00 | 3.97 | 3.73 | 4.79 | 61.67 | 100.00 |
| 22-26 | 0.96 | 10.09 | 0.20 | 12.65 | 0.00 | 8.89 | 5.45 | 1.55 | 60.22 | 100.00 |

## Correlation Analysis

An attempt has been made to determine a correlation between all the features and distances to know how they change as the distance from the city increases. To measure the correlation, the mean distance of each zone from the city center is taken as 'x', and different features have been taken as 'y' variables. The result (Table 2) shows a significant relationship.

**Table 2**

*Degree of Correlation Between Distance and Different Features.*

| "x" variable | "y" variable (different features of fringe) | "r" |
|---|---|---|
| Distance between the zones and city centre | Population density | -0.99 |
| | Household density | -0.99 |
| | Sex ratio | 0.90 |
| | Growth rate | -0.05 |
| | Literacy rate | -0.90 |
| | Percentage of non-agricultural worker | -0.99 |
| "x" variable | "y" variable(Major type of land use) | "r" |
| Distance between the zone and the city center | Non-agricultural land use | -0.60 |
| | Permanent Pastures and Other Grazing Land | 0.63 |
| | Culturable Waste Land | -0.70 |
| | Fallows Land other than Current Fallows | -0.90 |
| | Current Fallows Area | -0.85 |
| | Net Area Sown | 0.90 |

## Importance of Raipur City and its Fringe Through its Regional Setup

Raipur city is located in the Mahanadi Basin in the heart of Chhattisgarh. The city is now the capital of Chhattisgarh and the commercial hub of different minerals and power resources. Notable among these energy resources are coal, steel, aluminium and power. As one of India's richest cities, Raipur is India's largest iron and steel market. According to the Details Project Report for Financial Assistance under JnNURM, 2013, coal, electricity, steel, aluminium, etc., industries are spread throughout the entire Raipur urban aggregate area. Hence, the commercial and Industrial development is taking place in the fringe region of the development area (nagarnigamraipur.nic.in).

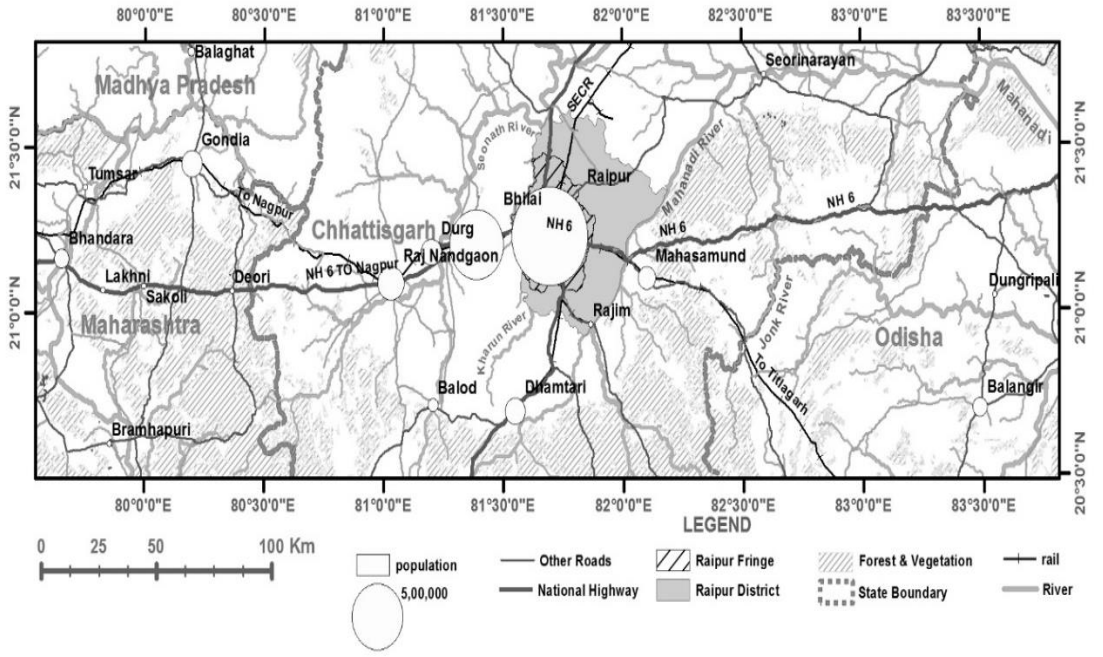
A look at the industrial profiles of the city and adjoining areas shows that there are more than 200 steel rolling mills, more than 195 sponge iron factories and more than 35 Ferro-alloy plants. In agriculture and forest-based industries, there are more than 500 agro-based industries and more than 60 plywood factories in the region. More than 800 rice milling plants are currently in production in the entire region (DPR Raipur, 2013). Some notable industrial areas of Raipur are Urla, Shiltara (heavy and medium scale industry), Bhanpur, Ganodwara, and Birgaon

(medium to small scale industry). Raipur is also emerging as a place of tourists for its ethnic art and culture. In addition to these issues, transport and communication greatly increase the importance of a city.

Being the state capital, Raipur city is well connected with other large and important districts and cities of the state and the country by road and rail network. Raipur is located along the Mumbai Howrah railway route under the South Eastern Central Railway Zone, one of the most created zones of the Indian Railways. The railway connects with Kolkata, Rourkela, Tatanagar, Durg-Bhilai, Nagpur, Mumbai, Delhi, etc. Some other important nodes connected with Raipur are Gwalior, Jabalpur, Amritsar, Jamshedpur, Pune, Visakhapatnam, Thiruvananthapuram, Patna, Ahmedabad, Gandhinagar, Jodhpur, Jaipur, Bhubaneswar, Secundrabad, Lucknow, Kanpur, Gorakhpur, and Bangalore (DPR Raipur, 2013). Besides the rail routes, some important National highways also connected Raipur to other metropolitan and mega cities all over India.

**Figure 16**

*Regional Setup of Raipur City and its Fringe*




NH 6, connecting Mumbai and Kolkata, passes through Raipur (Figure 16). Raipur and Visakhapatnam are connected through NH 43. NH 200 connects Raipur, its Industrial growth points like Siltara and Urla, and other potential mineral regions. Besides all this, Swami Vivekanand Airport of Raipur has recently become the third busiest airport in terms of passenger traffic in domestic flights to Delhi and Mumbai (DPR Raipur, 2013).

## Conclusion

Chhattisgarh emerged as a separate state on November 1, 2000, which led to increased urbanisation for Raipur, the capital city. The demographic features and land use successfully reflect the typical dynamic nature of a rural-urban fringe. The correlation analysis has proven a negative and a positive relationship with distance and other variables of fringe area. In this case, it has been observed that the rate of change of different parameters is less between 1991 and 2001, in comparison to that between 2001 and 2011. In fact, on November 1, 2000, Chhattisgarh emerged as a separate state, so after 2000, the urbanisation of Raipur, the capital of Chhattisgarh, would naturally increase much more.

Raipur city and its fringe region hold paramount importance from various perspectives, making it a key regional, industrial, and locational hub. Regionally, Raipur serves as Chhattisgarh's administrative and economic epicentre, pivotal in the state's growth and development. The city's strategic location in central India enhances its connectivity, serving as a crucial transit point for trade and commerce. Industrially, Raipur is renowned for its steel and power industries, contributing significantly to the nation's industrial landscape. The city's proximity to mineral-rich regions has attracted major industrial investments, fostering economic growth and employment opportunities. From a locational standpoint, Raipur's position on the Howrah-Mumbai railway line and the National Highway 6 further bolsters its significance as a transportation and logistics hub, facilitating the seamless movement of goods and people. Raipur's multifaceted importance underscores its role as a vital player in the regional and national socio-economic landscape. Looking at all these facts, it becomes unequivocally evident that Raipur city is poised for an exponential surge in urbanisation in the imminent future. Consequently, in fostering sustainable urban development, the fringe area of Raipur city assumes a crucial significance.

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***Geo-Reflections-6***

# Dismantling Hierarchy and the Epistemological Concerns in Empirical Research

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The 'field research', crucial to the genuine representation of the real world, preferably called space and place by Geographers, is an essential component of research and writing to advance the knowledge production in Geography. Although critical philosophies have been developed over more than four decades, the processes and methods of fieldwork, especially in Indian geography, are still dominated by objective data collection methods influenced by the spatial science approach and positivist philosophy. Through scientifically collected quantitative data, which can be tested to prove the accurate interpretation of space and place, the epistemology in Geography is also obsessed with bringing scientific rigour to compete with the mainstream sciences and to retain its position within the faculty of sciences in the Indian University system. In attempting to prove its scientific standing, the discipline continues to follow the same path uncritically, even after decades of critical geographical analysis practised in different countries. For this reason, fieldwork still depends heavily on scientific methods hired from scientific disciplines. Geography's epistemological process is biased towards science despite having the human at the centre stage of the discipline.

As part of an academic series written in popular mode, this article highlights certain concerns and challenges in the process of knowledge production or epistemological standpoint in Geography. The article, based on my field experience

Invited Article

over three decades carried out in many different contexts and places, questions the uncritical acceptance and use of certain terminologies and methods in our field research and uncovers the hierarchy hidden in the process of knowledge production. Examining our limitations and problematic perspectives in fieldwork may help us better understand what we do and how we do it. Ultimately, these processes will allow us to develop new epistemologies free from hierarchical baggage.

The process of knowledge production through empirical research vis-à-vis fieldwork has enormous importance in the growth and development of many disciplines of social sciences in general and geography in particular. Therefore, this article's scope is much broader and covers all the disciplines of social sciences which conduct fieldwork with humans as their research participants. The article raises some concerns to improve the epistemological standpoint of all these disciplines. Here, I must clarify that I am using the term epistemology in reference to the specific concerns of fieldwork and, more specifically, the data collection process.

## Deconstruction of Problematic Terminologies

Language and terms are very powerful tools in maintaining hierarchy, which is also applicable in the case of empirical research. We often use certain terms in our day-to-day mundane research and writing without giving much thought to the hierarchy ingrained in those terms. I prefer to say that we accept those terms uncritically without questioning their history and context. The first one I would like to discuss is ‘sample’. While presenting my research as a young researcher on different platforms, I often encountered two questions—how many samples have you taken in your research, and how did you choose them? The same question is probably being asked even today without considering *who* those samples are.

I always felt uncomfortable when my research participants were being narrowed down to mere samples by other academics during those conversations. I still hear the term often during discussions on the same kinds of occasions, especially during the presentation of research findings by other scholars. In my empirical research process, the social bond with my research participants played a significant role in data collection, and my research output is often co-produced through interactions with them. Therefore, the contribution of my research participants is enormous in my field research, and that is why defining them as mere samples is beyond my imagination. However, the term is still in use among most researchers within our discipline, which needs rethinking. To do so, we need to understand the roots of the coinage of the term and its strong scientific background.

In the disciplines of Pure Sciences, research rarely deals with the human as a prime research subject, except in Applied Sciences such as medicine. The term ‘sample’ is appropriate in their disciplinary language as they mostly deal with material objects as the subject of their research, such as soil, minerals, rocks, water, and air, besides some organic substances such as plants and animals. However, in

proving that Geography deserves the status of a science, we have forgotten that we mostly deal with humans as our research subjects, and they are neither inert materials to be tested nor mere plants and animals to be examined. This problem is endemic in our epistemic process as we always try to place Geography as a science. For that, we often copy models and language from Pure Science disciplines. Using such terminology uncritically does not help us; it complicates the knowledge production process and limits the research.

As soon as we define the research participants as samples, we create a hierarchy which limits the participation of people who are the subject of our research and the source of the knowledge as experienced and perceived. Using this term creates a hierarchy by putting the researcher in a higher position and devaluing the contribution of research participants in the entire process of empirical research and knowledge production. Recently, there has been a change in terminology from ‘sample’ to ‘respondent’, but it does not remove the hierarchy involved in the epistemological process. The term ‘respondents’ also treats them as naïve subjects who are only eligible to respond to our questions but are not encouraged to question us or our knowledge production systems. We cannot demolish the hierarchy and co-produce well-balanced knowledge from our field research as long as we continue using these terms. Only research participants can actively participate in our research process and complement our knowledge to make it inclusive and to overcome our epistemological limitations.

Another term we often use in our academic writing, especially in the case of the built environment, is ‘unplanned’ development. In saying so, we uncritically accept that every built environment should be planned, which finally makes planning a norm. Why do we consider that planning is necessary and obvious? Most research on cities of the Global South ends with a recommendation that they ‘need proper planning', although the term ‘proper’ is not always very clearly defined, even in the minds of those authors. Thus, planning is an epistemological baggage in the urban studies of the Global South, and we often accept and use this term uncritically.

In most cases, planning is a process of exclusion and tends to be biased towards particular demands of certain groups of people. Even if we talk about participatory planning, the existing literature and experience from different countries show that planning is often done by some elite groups, often called urban planners, who work under some corporate companies. They do seek to make the city better-managed and liveable, but not for everyone. The planning process usually recommends the exclusion of poor and marginal communities from the cities and facilitates dispossession. To validate these ideas and implement these policies in our cities, we hire another genre of terms from the Global North, such as redevelopment, gentrification, beautification, etc. Planning makes it easier for either big corporate or local private companies to acquire land and do business for real estate and infrastructure development. Thus, planning is not necessarily a nice or altruistic proposition, and using the term 'unplanned' makes way for such planning.

Redevelopment and gentrification projects are sometimes so exclusionary and brutal in practice that scholars (Burte & Kamath, 2023) define these processes as part of structural violence against some community groups. This process often either evicts the poor and underprivileged or redevelops their habitats, called slums or informal settlements. Such slum redevelopment is targeted to acquire a major share of the land for other kinds of commoditised development activities by pushing slum people into multi-storied buildings occupying a small portion of the same land by allotting a tiny flat for each household. Scholars like Bhide (2023) and Kundu Satija (2023) also interpret these processes as structural violence. Here, I must also dig deeper into the term 'informal settlements'. We often use the term to define settlements that are not legally constructed as per the city government's regulations, and people do not have tenure security. At a time when middle-class people are failing to access housing in cities, how can the poor pay the cost of highly-priced land in a metropolitan city? The informal settlement is also a category created to label poor people's housing in a city, defined as 'constructed/planned illegality' by scholars (Bhan, 2013; Clerc, 2018). Thus, when we use the term 'unplanned', often the nature of informal settlements and lower-middle class or poor neighbourhoods, the underlying meaning advocates that these settlements should not be there. When we demand planning, we naturalise such an exclusionary process of change. Urban Planning is often a corporate business; big multinational companies from Europe and America often plan for the Global South's cities. Even if Indian companies do it, they usually follow the Western planning and design model irrespective of the completely different context, climate, and local environment of Indian cities.

Moreover, the plans are often long-term, and these long-term plans, called 'master plans', often fail because of the mismatch between anticipation of the change in the city over the next 20/30 years and the actual change. Therefore, long-term planning is facing severe criticism worldwide, and the demand for contingent short-term planning is rising. Scholars like Bhan (2019) argue that in understanding and managing the cities of the Global South, we need to move away from the epistemological baggage of 'planning' and look into how cities are built through autoconstruction. To define autoconstruction, Caldeira (2017, pp. 3–20), in her work on peripheral urbanisation, states, 'residents are agents of urbanisation, not simply consumers of spaces developed and regulated by others. They build their houses and cities step-by-step according to the resources they can put together at each moment in a process that I call '*autoconstruction*'. Thus, autoconstruction is the contingent change within cities and their neighbourhoods where people participate and negotiate with the state. In contrast, planning is, in most cases, a one-way change where state machinery has full control and people have no participation. Thus, we must think deeply before using the term 'unplanned' and recommending 'planning' everywhere. Before recommending planning in response to every problem, we must reconsider the hierarchy and power structure involved in the planning process.

## Structured Questionnaire and the Field

A structured questionnaire is a preferred research method among Geographers, especially for those who still believe that Geography is nothing but a spatial science. Structured questionnaires help quantify the information gathered from the field and make it easier to apply higher statistical techniques and, consequently, objective analysis of the real world. However, structured questionnaires are limited by the restricted response options given by the researcher, and there is no scope for research participants to express their views if they go beyond the given structure and options.

When I question the structured questionnaire as a method of fieldwork, I do not only challenge the pre-determined way of collecting data, which can be easily quantified, but also the hierarchy built in that method between the researcher and the research participants, putting the researcher at a superior position and ignoring the perceived knowledge of the persons whose space/place we are going to narrate or explain in the process of knowledge production. In the process of using this method, it is thought that we, the researchers, owing to our formal institutional knowledge background, know the world much better than people who have little or no institutional knowledge. However, during my long field research career spanning over three decades, I observed that the epistemological position of my research participants is no less than ours. Rather, they can challenge our knowledge background and structure.

To explain this context, I would like to take an example and narrate my encounter with one research participant during fieldwork to understand his assets and livelihood portfolio. The man was a small farmer living on a river island. Through the interview, I was trying to understand his farm work's yearly income and profit level, especially from the different crops he cultivates. When I was about to leave his house after the interview, the man suddenly told me, “Madam, you asked about all kinds of livestock resources, but you did not ask about my cats.” According to our formal knowledge, we do not count cats as livestock resources as they do not have sale value and cannot be transformed into money. But the man insisted that I should accommodate his cats in the database. I asked him, “Why do you want those cats to be included in your livestock resource database?” His answer was very clear and logically explicit. He gave me a proper description of how, after keeping four cats, he could save a huge amount of paddy and jute bags for storing paddy that mice otherwise destroyed every year. He could calculate the money he saved yearly because of those cats. I was spellbound by his argument and articulation of those animals' contributions. This interaction triggered my understanding of how important it is to accommodate the knowledge of research participants in the process of knowledge production in specific cases. Otherwise, our hierarchical epistemology will never represent the real world narrated and explained through our one-sided empirical research.

Such a hierarchy complicates our understanding and portrayal of the real world and has become one of the central epistemological challenges in Geography. The epistemology practised in this process is, therefore, a problematic one and biased towards the researchers themselves by not giving enough importance to the perceived experience of the research participants, which we claim as our posterior observation and which lies at the core of empiricism as a philosophy of understanding the real world.

The question arises: How can we dismantle this hierarchical position in framing questionnaires? We must use this method in our research to deal with a large number of research participants. However, minor modifications in the questionnaire's structure can help us to accommodate the experienced knowledge of research participants. Semi-structured questions and open-ended questions can help in this direction to dismantle the hierarchy in the research process, and in doing so, it is significantly important to understand how we frame those questions. Openness in the questions and joint involvement of the researcher and the research participants can help in the co-production of knowledge. We can start by accommodating and investigating the 'other' option in the questionnaire.

## Dismantling Hierarchy and Acknowledging the 'Other'

We often use one category in our questionnaire called 'other'. What is this other? It is the amalgamated category of those probable answers which are not there in the knowledge background of a researcher. In this process, our first mistake is to keep 'other' as just one category rather than detailing the answers coming under that category. The 'other' may be a significant clue to where our structured knowledge is limited and what the research participant can contribute to the knowledge production through their experienced knowledge. Therefore, rather than treating the 'other' as a single category, we must be open to documenting all answers coming under that category. Under this particular heading, many crucial answers might emerge, which can improve our epistemological process on any particular subject to a great extent. Moreover, the 'other' allows us to dismantle the hierarchy between the researcher and the research participants, even within a structured or semi-structured questionnaire.

Changing our methodology from structured questionnaires to more open and qualitative methods can solve the hierarchy problem in the research process and fieldwork. A social bond must be developed between the researcher and the research participants to break the differential status and set a level playing field. Otherwise, there is always a chance of error. For instance, during my third interview with a young married woman, she changed her initial statement completely. She cited the reason as not knowing me enough to trust and to share her personal experience with me earlier. Thus, repeated visits also help us to gain trust and inspire confidence to share the truth.

The group discussion method is often used as a powerful qualitative research method. However, it can also elicit non-true observations without a level playing field between the researcher and the research participants. Once, I conducted a group discussion for one women's self-help group in a village in the erstwhile Burdwan district. The group consisted of female members from both the Hindu and the Muslim communities, and the leader was from the Muslim community. The discussion was held in the leader's house. The conversation went very well, and during that process, I asked them whether this group activity had helped to demolish the social division between these communities in the villages, where untouchability was also in practice. They all said the group activity helped them overcome the social barrier between these two communities. At the end of the meeting, while I was walking back to the nearest bus stand, some Hindu women were accompanying me as their neighbourhood was closer to the bus stand. In the villages, there was a clear division of neighbourhood areas between these two communities. While walking with them, one woman suddenly chastised me by saying, “Being a Hindu woman, how could you use the toilet of our Muslim leader?”

I was amazed to hear that statement from her; as a researcher, I started questioning my observations from earlier conversations with these women one hour before. Thus, knowledge, even if it comes from qualitative research, only sometimes leads to the whole, true knowledge. The methods we use in our study have to be carefully checked every time we go to the field. We have to pose the same question, or at least the proxy of that, again and again to our research participants. Personalised questions often lead to false or untrue answers unless we develop a social bond with our research participants, and to develop that bond, we must break the hierarchical status quo and accommodate our research participants by giving enough weightage to their views in the process of knowledge production. It is thus essential to situate or place research participants as co-producers of knowledge rather than treating them just as a respondent or a sample.

## Conclusion

In this popular piece, we need to rethink our epistemological processes and reconsider the problematic terminologies through the lens of the hierarchy hidden within those processes and involved in those terminologies often used in the Social Sciences. Lahiri-Dutt (2020) has explained how new water epistemology is important in the studies of water. Similar attempts are also being observed in different genres of studies, such as urban studies. Trained as a Geographer, my interest is in its epistemological challenges. The challenges are many, and I could not make an exhaustive list and explain them all. I open the platform to the young social sciences researchers in general and Geography in particular for further questions and interrogations in their empirical research. The predominant approach practised in Geography is holistic. Natural Science and Social Science, as well as nature and culture, all blend well in Geography. There is no point in carrying forward the

epistemological baggage of Natural Sciences in our research, thereby unquestioningly continuing with a hierarchical research process. Why don't we accommodate the perceptions and voices of research participants in knowledge production, as the 'human' is at the centre stage of our discipline? The co-production of knowledge is of utmost importance in the epistemologies of space and place, and for this, the dismantling of hierarchy is an absolute necessity. To bring about those changes, we have to start with little things—changing our terminologies, imbibing more open and qualitative research methods, developing social bonds with the research participants to gain trust and their real opinions, and finally, accommodating the experienced knowledge of the research participants on the particular issue or topic of discussion.

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| Names and addresses of individuals who own the journal and partners, sharing more than one per cent of the total capital | Association of Population Geographers of India |

I, Nina Singh, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Dated: December 2023 Signature of Publisher

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