J-Gate INDEXED

ISSN 0970-809X

GEOGRAPHICAL PERSPECTIVE

A JOURNAL OF THE ASSOCIATION OF GEOGRAPHERS, BIHAR & JHARKHAND

Volume - 26 October, 2025

Annual Peer Reviewed Journal

THE ASSOCIATION OF GEOGRAPHERS
विश्वम्भरा वसुधानि प्रतिष्ठा
Estd. 1999
PATNA

Published by :
THE ASSOCIATION OF GEOGRAPHERS
BIHAR & JHARKHAND
DEPARTMENT OF GEOGRAPHY
PATNA UNIVERSITY, PATNA - 800 005
Email : agbj2003@gmail.com
Website : www.agbj.in

Volume - 26 GEOGRAPHICAL PERSPECTIVE October, 2025

THE ASSOCIATION OF GEOGRAPHERS
BIHAR AND JHARKHAND

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GEOGRAPHICAL PERSPECTIVE
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Composed & Printed by ***Calligraphy Printers***, Patna, Mob. : 9835063933 | Email : calligraphyprinter@gmail.com

ISSN 0970-809X

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PATNA UNIVERSITY, PATNA-800 005
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Editorial Column

Dear Fellow Readers

I am privileged to have a team of scholars who use to burn mid-night oil to review, edit and do necessary changes in the submitted research papers as peer reviewers, editorial board members and members of advisory committee. Their scholarly exercises have lighten the load over me, I am very thankful to them.

This is the 26th Volume of the Journal. I am confident that the contents of this volume shall be very helpful to teachers, researchers and learners. There are 20 research papers having three important components. First, most of the papers are based on small area study and findings are found very relevant. Secondly, most of papers also cover contemporary issues related to climate change, environment, sustainable development, recent trends in urbanization and migration, new fields of resource reserves, spatial pattern of health education and food security. Thirdly, researchers have used new methodology particularly geo-spatial technology and pragmatic approaches.

I am also aware of the facts that no research work could be complete. There are always chances of further investigations. I hope readers will keep this in their minds while assessing the contents of the research paper. Editorial board members and peer reviewers were also serious to suggest necessary addition, deletion, re-ordering the contents and grammatical/liguistic corrections wherever needed. I am happy to state that paper writers cooperated in the phenomenal way through incorporation whatever suggestions were sent to consider.

Consequently, quality research papers have been included. Altogether 35 research papers were submitted but only 20 papers could find place in this volume of the Journal. All efforts have been made to publish only quality research papers, but no one can say that these papers have no grey areas. I would like to welcome your suggestion not only on the presented research papers but also on the issues related to publication. I, on behalf of the editorial board assure that relevant suggestion will be taken into effective consideration in the next volume of the Journal.

I further seize the opportunity to congratulate the office bearers and the executive committee members of the Association of Geographers, Bihar and Jharkhand (AGBJ) for providing financial and logistic support in the publication of the Journal. The Journal will be released at the 26th Annual Conference of the AGBJ at V.B. University, Hazaribag on Oct 11, 2025. Thereafter, it will be made available to the readers.

Rash Bihari Pd. Singh

(Rash Bihari Pd. Singh)
Editor-in-Chief

Geographical Perspective Vol. 26, October, 2025 ISSN 0970-809X

CLIMATE CHANGE AND AGRICULTURE: AN ASSESSMENT AND ANALYSIS OF POLICY INTERVENTIONS UNDER BIHAR PERSPECTIVE

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Introduction

Climate change stands as one of the most critical challenges of the twenty-first century, profoundly influencing the trajectory of our shared future. Its impacts are already evident, causing substantial disruptions to agriculture and ecosystems (IPCC, 2022). It is expected to further impact directly and indirectly the agri-food system. The extent of these impacts will depend not only on the intensity and timing of the changes but also on their combination, which are more uncertain, and on local conditions. As evident, global mean temperatures have increased by more than 1.2°C since industrial revolution (Hantemirov et al., 2022), although the rate of warming varies by region based on land use and local climate. Also, there has been a noticeable rise in the highest temperatures in India, especially along a diagonal stretch across the nation (Roxy et al., 2024). India's average annual temperature has increased by about 0.7°C between 1901 and 2018, and estimates indicate that temperatures may rise by almost 5°C by the end of the century if greenhouse gas emissions are not reduced (Krishnan et al., 2020). India has already experienced unprecedented heat, with two of the hottest years on record being 2016 and 2020 (Rojanasakul & Eric, 2022). The effects of abnormal temperature and erratic rainfall are especially acute in India, where the economy is primarily agrarian and reliant on natural resources, thus threatening food security issues.

The state of Bihar, located in the middle Gangetic Plains, is blessed with fertile alluvial soils. However, it is considered as one of the most climate vulnerable states due to its unique geographical location, hydro-meteorological features, dense rural population, and high poverty. 14 districts out of the 50 most vulnerable Indian districts belong to Bihar possessing a high risk of earthquakes, floods, droughts, and strong winds (Dasgupta et al., 2020). The state's unique exposure to hydro-meteorological disasters with annual floods in the north and recurrent droughts in the south clearly highlights the vulnerability scenario of the state. Agriculture and animal husbandry is practiced as the major source of income for the 90%

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Note : The paper is based on 'Keynote Address' delivered at 25th Annual Conference of AGBJ, 2024.

population contributing to 21.3% share of the state's GDP (Govt. of Bihar, 2016). Bihar's livelihoods, biodiversity, water resources, and agriculture are all seriously threatened by climate change. The agricultural economy of Bihar is predominantly subsistence-based. The agricultural sector has already experienced significant impacts in recent years due to recurrent floods and droughts. The urgent need for resilience-building measures is highlighted by the main drivers such as small landholdings, inadequate infrastructure, a heavy reliance on rainfed agriculture, and limited adaptive capacity. Hence, it is vital to strengthen the resilience of agriculture to climate change through targeted adaptation strategies. Without such measures, agricultural outputs are likely to decline, endangering sustainable agri-food systems. Looking to all these aspects, the present article focuses on presenting climate-related changes in agriculture in Bihar and the necessary corrective measures being implemented in the state by the Government, University and other stakeholders.

Perceived Shifts in Agroclimate of Bihar

Bihar has witnessed considerable shift in rainfall pattern during the period 1984–2023 (Fig. 1 and 2). As shown in the Figures, there is a significant variation in the average annual rainfall pattern between the two climatic periods: 1984–2003 and 2004–2023 (Sattar et al., 2024). During 1984–2003, rainfall in the 900–1000 mm category was confined to the districts of Jehanabad, Arwal, and parts of Nawada, Nalanda, Patna, and Bhojpur. However, as evident from the thematic map, this rainfall category expanded to cover many more districts during 2004–2023. Conversely, areas receiving high-category rainfall experienced a sharp decline. The changing rainfall pattern across the districts of Bihar over these two periods is a matter of serious concern, particularly with regard to agricultural sustainability and the agro-ecosystem. Moreover, significant decrease in length of growing period (LGP) during the recent climatic period (2004-2023) as compared to the period of 1984-2023 was observed in almost all districts (Fig. 3 and 4).

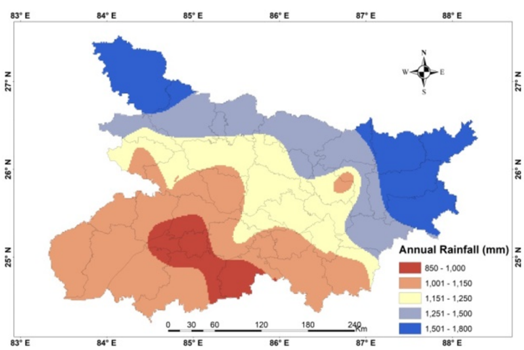

Figure 1 : Rainfall pattern over Bihar during the period 1984-2003

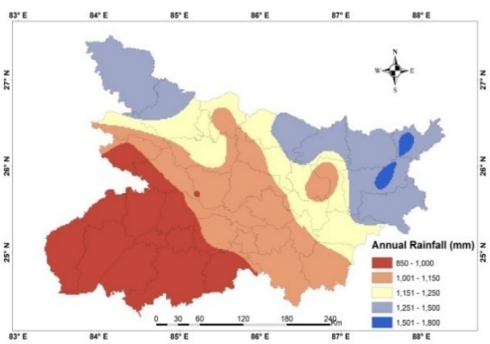

Figure 2 : Rainfall pattern over Bihar during the period 2004-2023

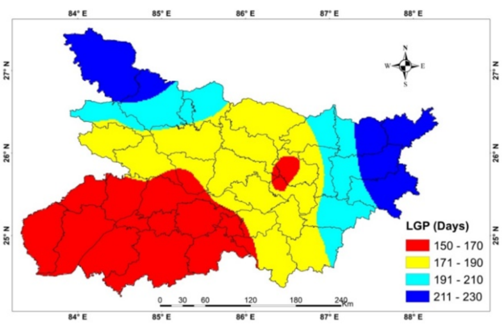

Figure 3 : Length of growing period (LGP) during 1984-2003

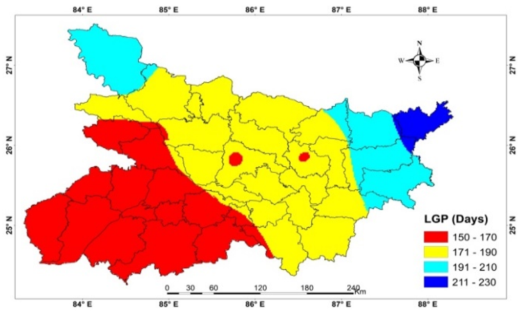

Figure 4 : Length of growing period (LGP) during 2004-2023

Climatic Perturbation and Agricultural Impacts

The data on extreme rainfall (case study: Pusa, Samastipur) and agriculture over the past several years highlights an alarming trend of weather extremes affecting crop production (Table 1). Almost every year, standing crops are exposed to the adverse effects of either heavy rainfall or prolonged dry spells, often occurring simultaneously. Considering long-term change in temperature, the maximum temperature has shown a decreasing trend, while the minimum temperature has exhibited an increasing trend (Figs. 5a and 5b).

The impacts of climate change on the major crops such as wheat, rice, and maize are expected to be severe, underscoring the importance of implementing effective adaptation and mitigation strategies. If the current rate of warming continues, simulation studies suggest that the average productivity of wheat may decline by 15–20% by 2050. Specifically, a decrease in wheat yield is projected to range between 4.9–12.0% for crops sown in November, and between 33.8–42.4% for those sown in December, by the years 2050–51 and 2080–81, respectively, under RCP 4.5 (Sattar et al., 2023). During 2008-2009, wheat yield declined by 20–30% due to elevated ambient temperatures in December and January as a result of significant reduction in tillering (20–35%) and poor grain formation. In this region of Indo-Gangetic plains, terminal heat is emerging as a major concern for successful wheat cultivation. Due to increasing temperature and frequent warmer nights during winter season in recent years, crop duration decreases leading to reduction in total biomass production and crop productivity.

In the case of *rabi* maize, low temperatures during December and January in Bihar often cause pollen sterility, limiting growth and yield due to the crop's cold sensitivity. However, a marginal increase in January temperatures could potentially improve the average productivity of rabi maize in the long term unlike other crops. Simulation studies predict an 8-10% increase in the yield of winter maize by 2099. Considering rice crop, it is highly vulnerable to erratic and variable monsoon rainfall (Sattar and Srivastava, 2021). Under conditions of poor or delayed rainfall, the viability of cultivating long-duration rice varieties becomes uncertain. Moreover, future climate projections indicate an increased likelihood of droughts and extended dry spells during the kharif rice growing season, which could severely impact rainfed kharif rice cultivation across the state. Kumar and Pareek (2024) have reported around 47% drop in rainfed rice yields by 2080 in the absence of adaptation. Under moderate warming, rising temperatures during critical growth stages could reduce rice yields by 10% to 20%.

Table 1: Extreme rainfall, Dry spells and Impacts

Scenario of rainfall		2017	2018	2019	2020	2021	2022	2023
Annual rainfall (mm)		1134.7	883.8	1146.1	1633.2	1883.6	835.4	1309.1
Rainy days (Jun-Oct)		45	43	39	52	62	36	40
Frequency of dry spell (Jun-Oct)	5-7 D	5	2	10	2	2	8	4
	8-10 D	3	2	6	0	2	4	2
	11-15 D	1	1	4	1	2	3	1
	>15 D	1	1	1	1	2	1	2
Heavy rainfall (Jun-Oct)	>75 mm			1 (Jul)			1 (Aug)	
	>100 mm	2 (Jul &Aug)	1 (Aug)	1 (Sep)		1 (Oct)	1 (Oct)	
	>150 mm				1 (July)			2 (Aug,Sep)
Agricultural Impact		Dry June, Sep and Oct. Very heavy rainfall in Jul and Aug created flood	*Kharif* as well as *Rabi* crops were damaged due to dry spell and flood	Drought in Jun and Jul severely affected transplanting	About 33 % of the total *Kharif* crops were damaged, Rainfall in July: 650 mm	24 days long dry spell in Oct. Extreme heavy rainfall in Oct. 13 districts were flooded	Drought like condition in Jun and Jul. Only 40 % transplanting	Drought in Jun and Jul. Severe effect on transplanting. Flood in Sept

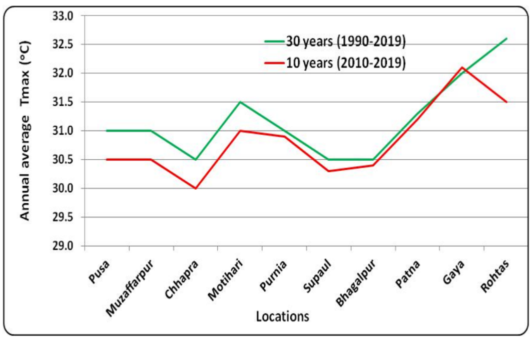

Figure 5A : Variation in annual average T_{max} over 30 years (1990-2019) and 10 years (2009-2019) periods at different locations in Bihar

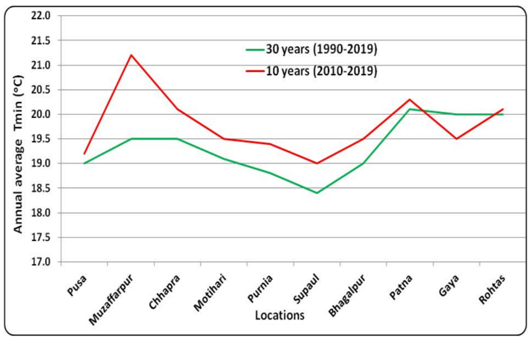

Figure 5B : Variation in annual average T_{min} over 30 years (1990-2019) and 10 years (2009-2019) periods at different locations in Bihar

Climate-smart Interventions for Risk management, Eco-system restoration and Enhanced farm Income

The Climate Resilient Agriculture (CRA) Programme launched in 2019 by the Government of Bihar addresses growing risks posed by climate change, particularly in flood- and drought-prone regions and enhances farmers' income. RPCAU worked as a key technical partner, contributing to technology development, capacity building, and field demonstrations across several districts of North Bihar. CRA practices encompass a suite of strategies such as the adoption of climate-resilient crop varieties, zero tillage, conservation agriculture, diversified cropping systems, precision water and nutrient management, crop residue management, and advanced tools like Laser Land Levelers. It is well established that CRA methods have consistently outperformed traditional farming practices, particularly in enhancing crop yields. For instance, Direct Seeded Rice (DSR) achieved a yield of 42.47 q/ha, significantly surpassing 36.61 q/ha yield from conventional method. Similarly, improved Nutrient Management (NM) practices yielded 41.05 q/ha, well above the 35.33 q/ha under traditional fertilization approaches. Beyond yield improvements, CRA approaches have provided other co-benefits like better input use efficiency, enhanced farm profitability, and lower greenhouse gas emissions. For example, terminal heat stress can be escaped through earlier wheat planting by 7-10 days under Zero Tillage (ZT). Additionally, ZT combined with crop residue retention is reported to enhance water use efficiency, soil health, and overall system productivity.

Laser Land Levelling, a laser guided technology to achieve uniformly leveled land further boosts returns by reducing irrigation time and energy use. It also ensures better water distribution and weed control leading to a 30% reduction in irrigation, 75% less weed growth, 17.7% yield increase, and significant climate mitigation benefits. Direct Seeded Rice (DSR), restricting soil erosion and preserving soil organic matter along with curtailing labour and water costs proves to be a practical adaptation for water-stressed regions. However, despite their proven advantages, the adoption of mechanized CRA technologies in Bihar remains largely limited to wealthier, large-scale farmers. To overcome this challenge and scale climate resilience equitably, greater investment is needed in infrastructure, capacity building, and policy support to ensure inclusive access to these high-impact interventions and sustain their long-term benefits.

Raised Bed Planting is a very important technology, which helped farmers to address both waterlogging and water scarcity by improving drainage and moisture retention. Crops such as maize, pigeon pea, soybean, and millet showed yield increases between 19% and 22%, along with a 30% reduction in irrigation needs. Precision Nutrient Management tools like Nutrient Expert, Green Seeker, and the Leaf Colour Chart guides in site-specific fertilizer application and results in 9–14% improved rice yields, 38% reduced nitrogen use, lower production costs, and minimized environmental pollution.

Crop diversification initiative encouraged farmers to reduce dependence on predominant rice-wheat cropping pattern of Bihar by integrating legumes, vegetables, and high-value crops. This enhanced soil fertility, improved food and nutritional security, and increased farm income, making the farming system more resilient to climate change. Replacing the late sown long duration rice with early sown medium duration rice provides sufficient window for summer crop ensuring better cropping diversity.

Strategic selection of stress tolerant varieties has been promoted to build up resilience through enhancing food security, adaptation and mitigation potential in agriculture. Rice grown in rainfed shallow lands suffers heavily due to the flash flood during the month of August, and experiences huge loss. Submergence tolerance gene incorporated rice variety like Swarna Sub-1 is being cultivated in those areas. This prevents considerable yield loss and stabilizes famers' income. In case of wheat, heat tolerant wheat cultivar (Rajendra Gehnu-1) assumes significance in the regime of increasing temperature during February and March.

Advanced RPCAU technologies and implements like Happy Seeder, Zero Till Seed Drill, and Super Straw Management System were introduced to enable residue incorporation and conservation agriculture for tackling the critical issue of residue burning in maize-wheat cropping systems of Bihar. Training and awareness campaigns reached over 2,000 farmers under the initiative covering almost 500+ hectares under non-burning practices. Outcomes included improved soil health, reduced greenhouse gas emissions, and enhanced water-use efficiency. Through GKMS Project, location-specific weather forecasts and crop advisories are provided to more than 50,000 farmers regularly in Bihar assisting for better planning of sowing, irrigation, pest control, and harvest, and significantly reducing crop losses during extreme weather.

The University is credited to have developed Sukhet Model. Hon,ble Prime Minister Shri Narendra Modi mentioned this sustainable approach for managing agricultural and organic waste at the village level in his *Mann Ki Baat* Programme. By promoting composting, vermicomposting, and bio-fertilizer production from cattle dung, crop residues, and kitchen waste, the initiative reduced open burning and groundwater contamination. It also created rural employment and awareness among farmers and women self-help groups (SHGs) for waste-to-wealth activities. The project promoted a low-cost, eco-friendly model that builds climate resilience at the grassroots level.

Innovative initiatives on Education and Research

The University has launched several initiatives to promote education and research in natural farming practices and digital agriculture. A School of Natural Farming has been established in the University with the objective of imparting education on sustainable and nature-based farming systems. In the field of digital agriculture, initiatives such as the Remote Pilot Training Centre and a 5G Lab at the University are contributing significantly to the advancement and adoption of digital technologies in the region. The development and implementation of a groundwater recharge-cum-drainage structure for low-lying areas has proven to be a boon for farmers. This technology not only enables timely sowing of rabi crops in waterlogged regions but also plays a crucial role in groundwater recharge. Research and application pertaining to solar energy by establishing solar trees and boat mounted solar pumping system for irrigation is a step forward to building resilience in agriculture. Additionally, the University is actively promoting research on millets, focusing on varietal development, crop production, value addition, and marketing. These efforts have opened new avenues of innovation to address the challenges of climate change and enhance farmers' livelihood options.

Conclusion and Way Forward

The impacts of climate change on agriculture and agro-ecosystems are increasingly evident, as many areas face challenges stemming from shifts in agro-climatic conditions. Climate resilient agriculture and other initiatives such as digital agriculture, natural farming, and millet research offer a transformative pathway to enhance agricultural sustainability, productivity, and resilience. Moreover, climate-resilient field interventions have already shown clear potential to improve input efficiency, reduce greenhouse gas emissions, and increase farmer incomes. Embedded on integrated and multi-institutional approach, they have created a robust model for climate adaptation in smallholder-dominated regions.

Given the changing dynamics of the agro-climate marked by increasing water deficits and reduced water availability, it is imperative to prioritize proven interventions and resilient technologies in agricultural production. Reduced emphasis on long-duration puddled rice, along with the promotion of aerobic rice, direct-seeded rice (DSR) technologies and climate-resilient crops and their varieties should be integrated into broader agricultural strategies. Hence, changing planting schedules, adopting climate-smart agricultural practices, using weather-based farm advisory services, diversifying crops, altering cropping patterns, adopting new crop varieties, developing stress-tolerant cultivars, utilizing alternative energy sources for irrigation, and managing climate risks based on local agro-climatic conditions are vital to effectively address region-specific challenges and enhance farm resilience. Establishing a strong foundation in research and education on climate-smart farming, digital agriculture, natural farming, varietal development programme, and genomics will significantly contribute to building resilient agriculture and improving farm productivity, ultimately bringing prosperity to farmers and the nation as a whole.

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APPLICATION OF GEOSPATIAL TOOLS FOR IDENTIFYING NEW SCHOOL SITES IN SHIMLA, HIMACHAL PRADESH

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ABSTRACT

Application of Geographic Information System and geospatial tools plays an important role in finding the suitable site for setting up of new schools for providing opportunities to every section of society. The present study tries to find the suitable sites for setting up new schools in Shimla. Both the qualitative and quantitative data are used for this purpose. GIS software like Arc GIS 10.7 and ERDAS Imagine 2021 used to create the geospatial data and further used in finding the new sites considering the various aspects, including proximity to population density, existing infrastructure, soil type, transportation, environmental sensitivity, and land use. The study reveals that only two sites are identified as per the criteria laid down in the methodology i.e. Theog block and Rampur block and the sites are found in the open and wasteland area of the respective blocks.

Keywords: *Educational Institutes, Geospatial Data, Land use Land cover, Regional Planning, Site Selection*

Introduction

In urban and regional planning, deciding where to build new educational institutes is a complex decision. It involves creating geospatial data of the existing schools (educational institutes), population density and its distribution along with the land use, which plays an important role in demarcating the suitable available land for setting up new educational institutes. Several studies conducted across different parts of the world have demonstrated the value of GIS-based multi-criteria evaluation (MCE) in school site selection. These approaches often combine environmental, physical, and socio-economic parameters to identify areas with the highest suitability for school construction. In urban regions of developing countries, GIS has been effectively used to identify underserved areas and ensure equitable access to education. For instance, spatial analysis has helped in visualizing educational service gaps and planning interventions to reduce travel distances for school children.

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In the Indian context, research using geospatial tools in educational planning has primarily concentrated on large urban centers. Studies have applied buffer analysis, network analysis, and overlay techniques to examine school accessibility and distribution patterns. However, the scope of such studies often remains limited to flat or moderately undulating terrains. There has been little emphasis on integrating terrain complexity, slope variability, and other mountainous characteristics into the spatial models for school site planning. Hilly regions such as Himachal Pradesh pose distinct challenges that are not commonly encountered in plain regions. The rugged topography, scattered settlements, and limited transportation networks significantly affect the feasibility of school locations. Despite these challenges, there is a noticeable absence of geospatial studies focusing on educational planning in such terrains. Most geospatial research in Himachal Pradesh has focused on areas like hazard zonation, land use change, or urban sprawl, with minimal attention given to education infrastructure planning.

Shimla, as a rapidly expanding urban center in the Himalayan foothills, requires careful planning to address disparities in school accessibility and land suitability. While studies have analysed urban growth and infrastructure stress in Shimla using remote sensing data, there is a lack of integrated geospatial studies that specifically address the need for new school sites. The complexity of the terrain demands a tailored approach that incorporates slope analysis, land stability, road connectivity, and population clusters to inform educational facility planning. In the last few decades, it is felt that the distribution of educational institutes, especially schools, are not well placed to cater the demand of the city according to the population distribution in Shimla municipality. Despite a good literacy rate, Himachal Pradesh still lacks proper educational infrastructure, leading to an increasing number of students shifting from government schools to private institutions. At the school, college, and university levels, students are facing the consequences of inadequate infrastructure, compounded by a shortage of teaching staff.

This research paper aims to create a geospatial database of educational infrastructure in Shimla District along with its land use pattern and population distribution to identify suitable sites for setting up new schools in the area. This study is concerned with the existing spatial patterns of schools and the identification of suitable sites for opening new senior secondary school with considering the various aspects, including proximity to population density, existing infrastructure, soil type, transportation, environmental sensitivity, and land use.

Literature Review

Education is an important tool for making society civilised and competent enough to harness the opportunities available across the globe. It's the duty of the government to provide the opportunity and accessibility of education to each section of the society across the region and in this process, Geographic Information System (GIS) can play an important as GIS is tool to collect geospatial data which helps in analysis and decision-making for not only in urban and regional planning but also in finding suitable sites for setting up of infrastructure like school, college, hospital, etc. for a sustainable city. Burrough (1986) defined GIS as "a powerful set of tools for storing and retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes." In last few decades, GIS has played a tremendous role in regional planning and suitable site selection for constructions. Today, the location component of data has become very important, with an estimated eighty percent of data containing a spatial aspect (Klinkenberg, 2003). The availability of location data has increased exponentially in recent years due to advancements in remote sensing, the Global Positioning System (GPS), and GPS-enabled smart devices. This growth has led to a surge in demand for GIS and web GIS. Now, most people, facilities, and phenomena can be referenced by location (Openshaw and Abrahart, 2000).

GIS offers significant utility for educational administrators by providing valuable analysis for planning and monitoring purposes. It enables data visualization, pattern identification, and delineation of school catchment areas, among other functions (Langley, 2001). Simon Choi and Ping Wang (2006) conducted a groundbreaking study on small-area school enrolment projections in Southern California. Their innovative approach integrates GIS and modeling methodologies to enhance the precision of school enrolment projections. Vern Svatos' 2003 study, "Locating Potential School Sites," introduces a methodology employing Arc View GIS for school site selection in Delaware. Svatos' research focuses on the study area, utilization of GIS themes, and the incorporation of various geospatial datasets. The study's innovative use of geo-processing techniques and the identification of additional data needs underscore its importance in advancing methodologies for selecting potential school sites.

Al-Sabbagh (2020) utilized a location allocation model to establish new schools in Mansura city, Egypt, aiming to enhance accessibility. The study considered several parameters, including the locations of existing schools, residential areas, demand points, and the transportation network. The area was divided into a grid of 100 × 100-meter square cells, selecting only those cells that met the criteria while discarding the rest. Through location allocation models and statistical analysis, suitable sites for the schools were identified. Similarly, Köse et al. (2021) conducted a study on preschool site selection in a province of Turkey. They analysed the distribution of existing schools to determine the need for new ones, using data on current preschools, population, roads, and Land Use Land Cover (LULC) to identify potential locations for new preschools.

Research Gap

A critical gap in existing literature is the absence of geospatially integrated models for school site selection in mountainous regions like Shimla, where topographical and infrastructural challenges significantly influence accessibility and feasibility. Although GIS-based planning has been applied in various urban contexts across India, it has not been adequately utilized for educational infrastructure in hilly terrains. Specifically, there is no comprehensive study that applies multi-criteria GIS analysis to identify optimal school locations in Shimla by considering both physical constraints and social needs. This research aims to fill that gap by developing a GIS-based framework tailored to the geographic and demographic conditions of Shimla, thereby contributing to evidence-based planning for equitable educational access.

Database and Methodology

Database: Both qualitative and quantitative data are used in this research paper. The land Use Land Cover map was downloaded from Bhuvan and georeferenced and vectorised. The data for the population was collected from the census department. In addition to these secondary data, published reports, journals, technical reports, and information from various departments of government of Himachal Pradesh and non-government sources were also consulted. Census data for population and data of schools have been collected from the Department of Education, Himachal Pradesh, 2011. The software used for data analysis are Arc GIS 10.7, ERDAS Imagine 2021, and MS Office. All the maps are georeferenced using appropriate projection parameters Projection (UTM, Zone- 43, datum WGS 84 N) in ERDAS Imagine 2021 and then digitized.

Methodology: A multi-criteria decision model is used for selecting an optimised site for a new educational infrastructure which is a systematic approach used for decision-making that considers multiple criteria or factors and based on the study of *Choi et al., 2006.*

The process involves identifying relevant criteria are shown with the help of fig. 1 and is self-explanatory. However, the criteria adopted for selecting an optimised site for a new educational infrastructure are given below:

- School should be 1 km away from the built-up area.
- School should be 1 km away from the National Highway.
- School should be 1 km away from primary school.
- School should fall in barren land.
- School should be built in an area where population size varies between 75,000-95,000 i.e. high categories as per the classification adopted in the study.

The rationale behind taking 1 km distance from built up area, national highway and a primary school for identifying new sites for school can be seen as a practical approach as it may minimise children's exposure to traffic-related pollution and noise, reduces accident risks, and avoids congestion or overlap with nearby institutions. Planners also commonly use 0.5-1.5 km buffers to define catchment/walking areas for primary schools; many policies (and practical safe-routes guidance) treat ~1 km as a useful planning radius for access and admissions priority in some jurisdictions. That makes 1 km useful both for safety and service-coverage planning.

Ideal Conditions for Site Suitability Analysis of Educational Infrastructure

The following are the ideal conditions for site suitability Analysis of Educational Infrastructure according to Choi et al., 2006.

i. Site Configuration and Accessibility: Ensure that sites have regular shapes with accessible road frontage to allow for efficient use and flexibility in school building placement. Ample space for potential expansion should be considered.

ii. Safe Circulation and Traffic Management: Prioritize safe access and circulation both internally and externally, addressing traffic management concerns. Consider provisions for various modes of transport, including school buses, pedestrian access, bicycle routes, and parking facilities.

iii. Ground Conditions and Development Impact: Seek sites with reasonably level ground conditions to minimize excavation or fill requirements. Avoid sites with poor ground conditions, rock formations, marshy areas, or archaeological features that could complicate development.

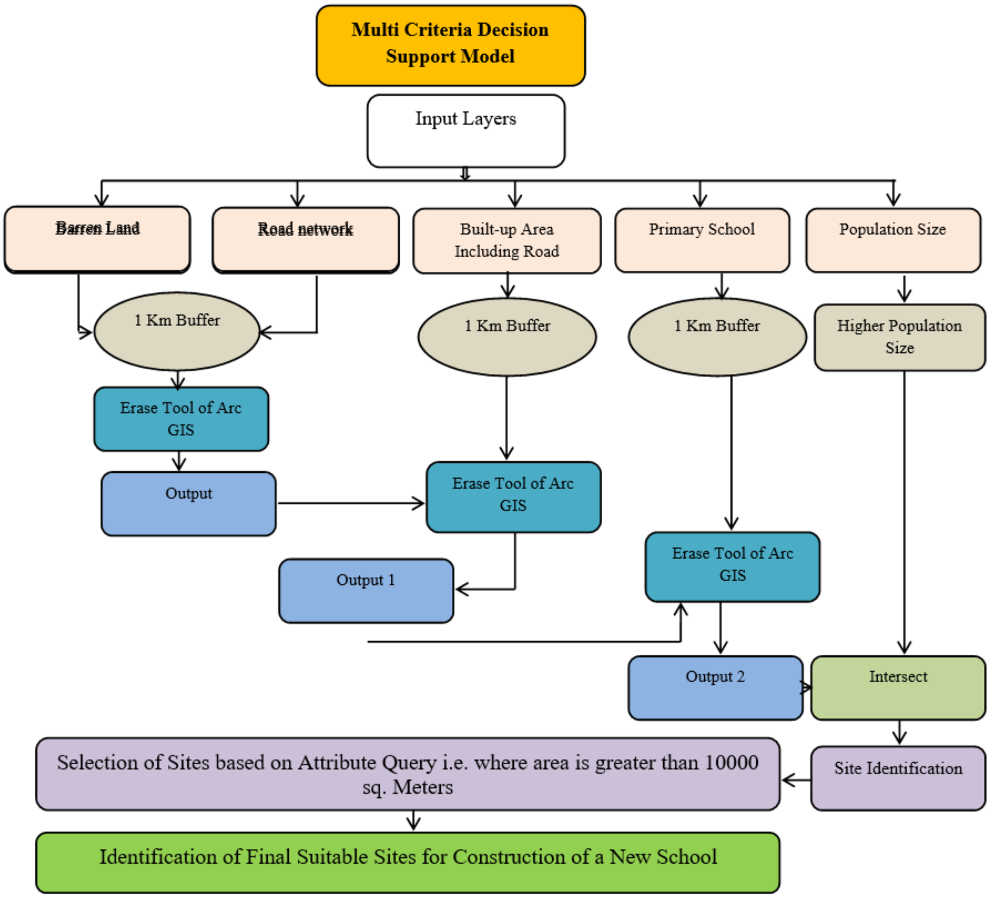
iv. Watercourse and Water Source Evaluation: Assess the proximity and impact of watercourses, rivers, lakes, wells, or aquifers on the site. Determine whether wastewater and surface water can be managed off-site or if on-site treatment and attenuation are necessary.

v. Groundwater Vulnerability Assessment: Conduct an assessment of groundwater vulnerability to understand potential environmental impacts. Consider mitigation measures to address any identified vulnerabilities.

vi. Infrastructure Considerations: Avoid sites with extensive over or underground services that would require significant and costly diversions. Ensure the feasibility of infrastructure development without imposing excessive costs.

vii. Existing Development and Site Integration: When the site is part of an existing development, consider factors such as residual site burdens, building lines, separation spaces, overshadowing, privacy concerns, external lighting, and ease of maintenance. Address safety and passive security measures.

viii. Climate and Exposure Considerations: Evaluate site exposure to minimize heat loss from the building envelope on exposed sites. Consider the impact of climate and weather conditions on the overall development.



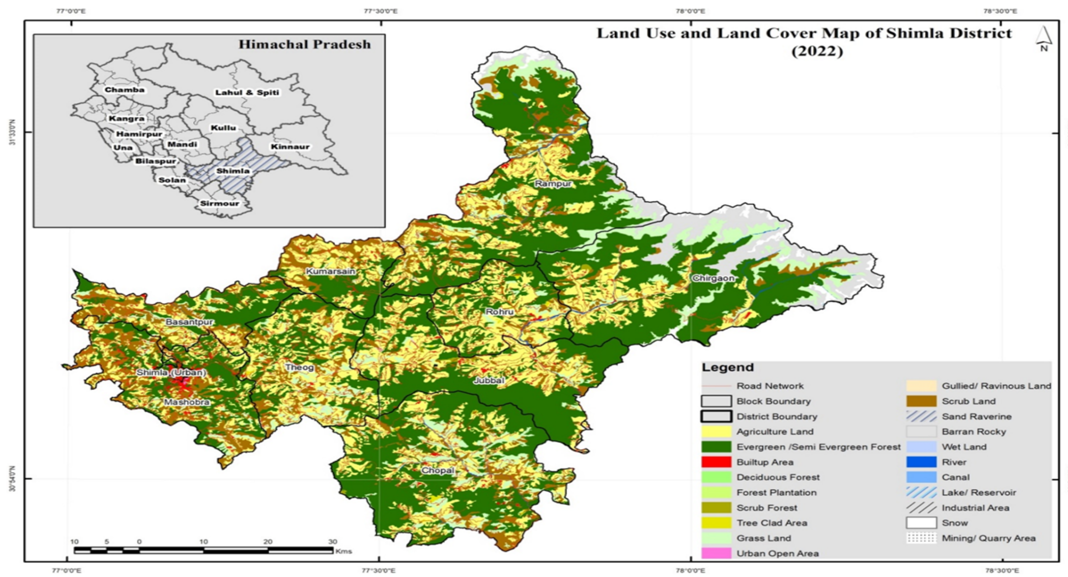
Source: *Based on Choi et.al., 2006*

Figure 1: Input Layers for Site Suitability Analysis

Result and Discussion

Land Use Land Cover

Shimla district covers 5131 sq. km area out of which agricultural land covers 1297.038 sq. km of area. Barren land covers 491.075 sq. km of area. Built-up covers 60.864sq km of area. Grassland covers 779.819 sq. km of area. The Waterbody covers 94.262 sq. km of area. Land use and land cover have been shown in fig. 2. Land use and Land Cover Map of Shimla District.



Source: *Information Extract from Resourcesat-2 (LISS -4) Satellite Image*

Figure 2: Land Use Land Cover Map of Shimla District

Relief Structure

The relief structure of Shimla, the capital city of Himachal Pradesh in northwestern India, is defined by its captivating hilly terrain nestled amidst the majestic Himalayan foothills. Situated at an average elevation of approximately 2,205 meters (7,234 feet) above sea level, Shimla presents a stunning landscape of interconnected hills, with the prominent Shimla Ridge running gracefully from east to west. These hills are adorned with lush forests of pine, oak, and deodar trees, creating a verdant and refreshing ambiance. The terrain is characterized by gentle to steep slopes, interspersed with picturesque valleys and ravines, forming a rich and diverse topography that offers breathtaking panoramic views of the surrounding natural beauty. The presence of the Sutlej River to the northwest adds to the region's allure, while smaller streams and tributaries contribute to the intricate river systems.

Types of Educational Institutions

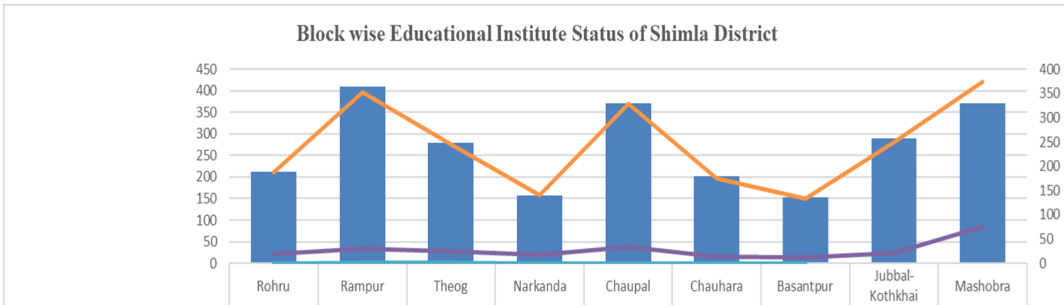
When considering educational facilities, they can be broadly categorized into two main types: Private and Public. Within the Private category, there are further subdivisions such as Unaided, Local Body, and Aided. On the other hand, all public facilities are managed by the Department of Education. Looking at the provided data table, we observe that Rohru block contains a total of 210 schools, out of which 188 are Government schools and 22 are private unaided schools. Rampur block hosts 396 schools, with 363 being government schools, 33 private unaided, and

1 central government school. In Theog block, there are 277 schools, of which 249 are government schools, 1 is a private aided school, 27 are private unaided schools, and 1 is a central government school. Narkanda block encompasses 159 schools, with 139 being government schools and 20 being private unaided schools. Chaupal block consists of 369 schools, among which 330 are government schools and 38 are private unaided schools. Basantpur block has 150 schools, with 136 being government schools and 14 being private unaided schools. Jubbal-Kotkhai block comprises 280 schools, out of which 257 are government schools and 23 are private unaided schools. Mashobra block boasts 421 schools, with 329 being government schools, 2 being local body schools, 4 being private aided schools, 84 being private unaided schools, and 3 being central schools.

In total, the district of Shimla houses 2,459 schools, with 2173 being government schools, 2 being local body schools, 271 being private aided schools, and 6 being central schools. Among the blocks, Rampur holds the highest number of schools, while Basantpur has the lowest count. Although the schools are well-distributed throughout the district, Rampur and Chauhara show a concentration of schools in the northwest region. Additionally, Rampur lacks distribution in the southeast region. This distribution pattern is visually depicted in fig.3.

Distribution of Educational Facilities

The educational landscape of Shimla district encompasses a total of 2,459 schools, with significant variations observed across different blocks. The block with the highest number of schools is Mashobra, leading with an impressive count of 430 schools, including 260 Primary, 49 Upper Primary, 17 Primary with Upper Primary, and 104 Senior Secondary schools.

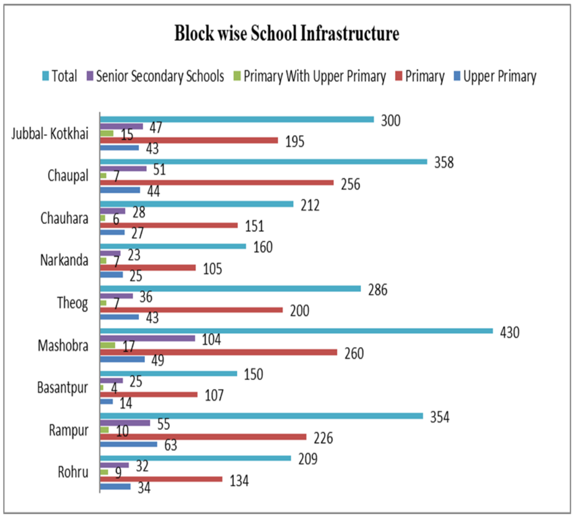


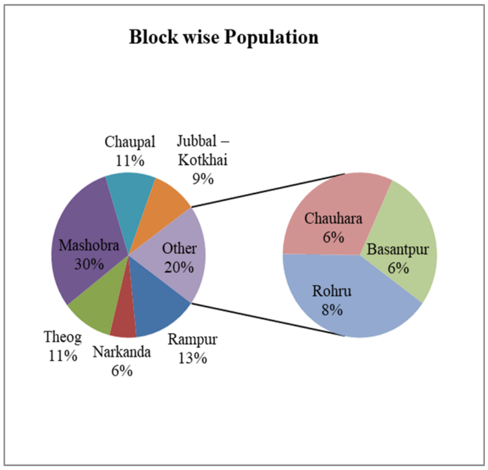
	Rohru	Rampur	Theog	Narkanda	Chaupal	Chauhara	Basantpur	Jubbal-Kothkhai	Mashobra
Boarding Schools	0	0	0	0	0	1	0	0	1
Private/Aided Schools	0	0	1	0	0	0	0	0	3
Government Schools	188	363	249	139	330	180	136	257	329
Private/Unaided Schools	22	33	27	20	38	16	14	23	84
Central/Government Schools	0	1	1	0	0	0	0		4
Total	210	396	277	159	369	197	150	280	421

Source: *Directorate of Education, Government of Himachal Pradesh (2011)*

Figure 3: Block-wise Educational Institute in Shimla

Following closely behind is Chaupal, with a substantial total of 358 schools, consisting of 256 Primary, 44 Upper Primary, 7 Primary with Upper Primary, and 51 Senior Secondary schools.





Source: *Directorate of Education, Government of Himachal Pradesh (2011)*

Figure 4: Block-Wise School Infrastructure **Figure 5 : Block-wise Population**

The third-highest contributor is Rohru, hosting 209 schools, comprising 134 Primary, 34 Upper Primary, 9 Primary with Upper Primary, and 32 Senior Secondary schools. In contrast, Jubbal and Kotkhai collectively provide a total of 300 schools, consisting of 195 Primary, 43 Upper Primary, 15 Primary with Upper Primary, and 47 Senior Secondary schools. Theog features 286 schools, including 200 Primary, 43 Upper Primary, 7 Primary with Upper Primary, and 36 Senior Secondary schools. Rampur contributes 354 schools, encompassing 226 Primary, 63 Upper Primary, 10 Primary with Upper Primary, and 55 Senior Secondary schools. Chauhara has a total of 212 schools, consisting of 151 Primary, 27 Upper Primary, 6 Primary with Upper Primary, and 28 Senior Secondary schools. Basantpur hosts 150 schools, with 107 Primary, 14 Upper Primary, 4 Primary with Upper Primary, and 25 Senior Secondary schools. Finally, Narkanda, with a total of 160 schools, comprises 105 Primary, 25 Upper Primary, 7 Primary with Upper Primary, and 23 Senior Secondary schools. The distribution of schools across the Shimla district is visually represented in fig. 4.

Population

Shimla district, with a total population of 8,14,010 encompasses a diverse range of population sizes across its various blocks. Among these, Mashobra block has the highest population, with a count of 86,782. Chaupal block follows closely behind, with a population of 85,244. Theog block contributes significantly to the district's population with 80,331 population. Jubbal–Kotkhai has a population of 74,012, while Rampur block has a substantial count of 71,887. Rohru block is home to 56,421 residents. Chauhara has a population of 52,514, Narkanada has population of 42,161, Basantpur has 41,724 inhabitants and Nankhari has population of 26238 in Shimla. This descending order of population showcases the varying demographic profiles within the Shimla district and is shown in fig. 5.

Barren land, road network, primary school, other built-up areas and population are taken into consideration for identifying the new location site for the school. Buffer map of 1000 meters around the road, buffer of 1000 meters around primary schools, and buffer of 1000 meters around the built-up area are made with the help of Arc GIS and also shown with the help of fig. 6 (a), fig. 6 (b) and fig. 6 (c) respectively and are overlayed. After that, the barren land map is erased from the road surface to get the first output, and then after school buffer is removed from output 1 to get output 2 which is further overlayed on the land use land cover map of Shimla to get the best suitable location for new school construction. Fig. 6 (a), 6 (b), 6 (c), 6 (d) and 6 (e) are the mapping of different layers for site suitability analysis for new School. Fig. 7 is showing the suitable sites for the new school.

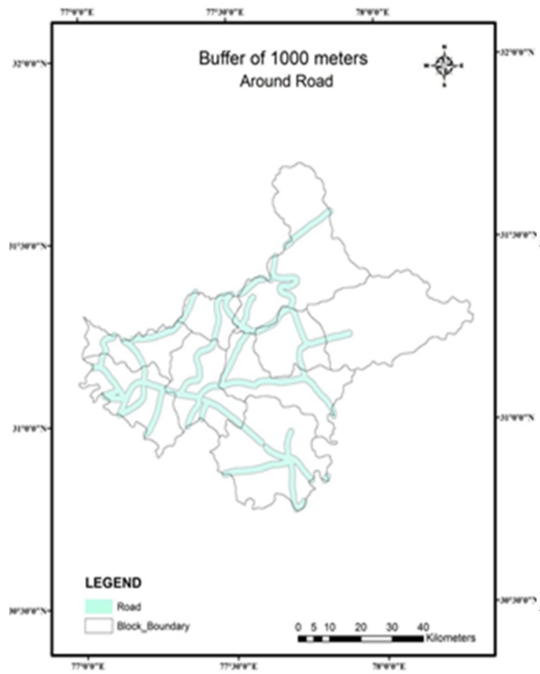


Figure 6 (a) : Buffer Around Road

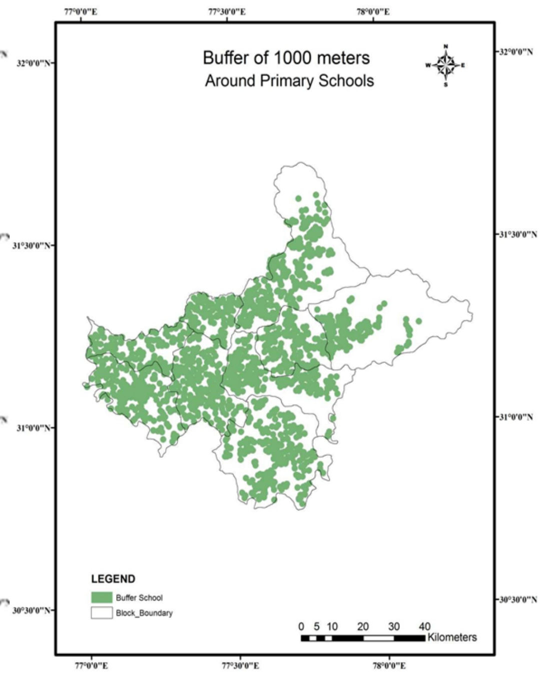


Figure 6 (b) : Buffer Around Primary School

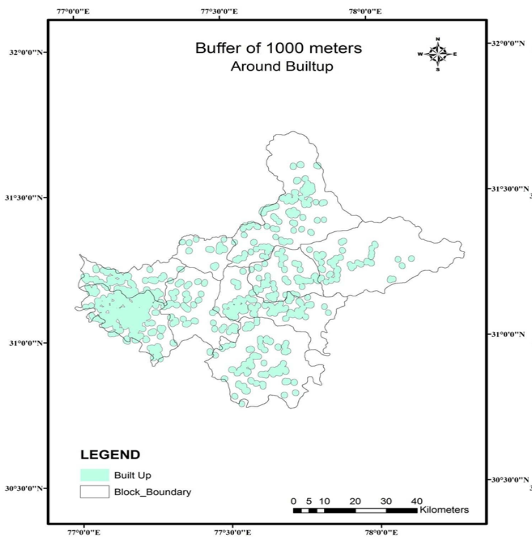


Figure 6 (c) : Buffer Around Build-UP Area

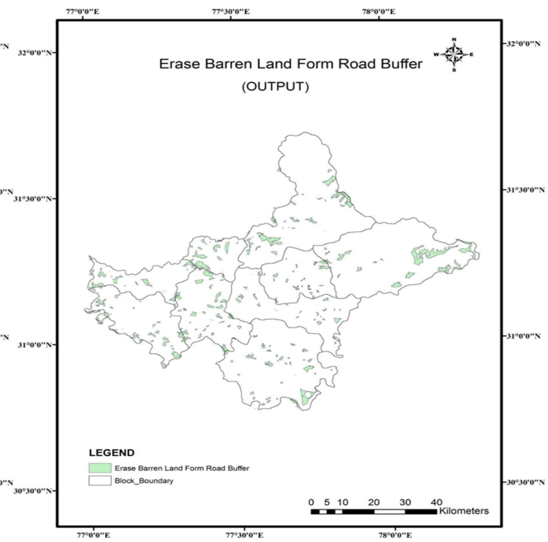


Figure 6 (d) : Erase Barren Land from Road Buffer

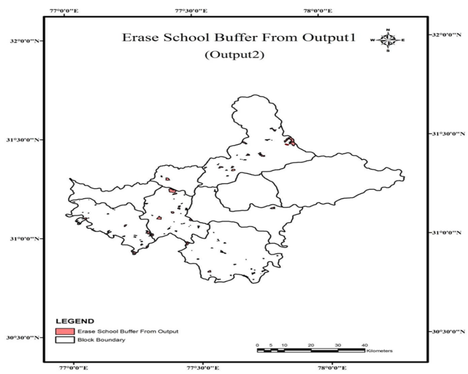


Figure 6 (e) : Erase School Buffer from Output 1

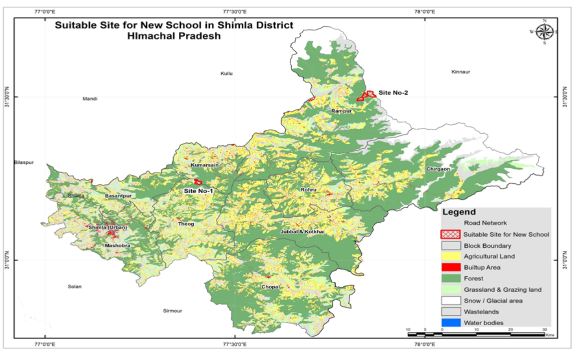


Figure 7 : Suitable Site for New School

Conclusion

The study shows the final suitable sites as per the criteria laid down in the methodology. The study shows that only two sites are identified as per the criteria in the Study area. Out of these two identified sites one has been identified in the Theog block and another area has been found in the Rampur block. The study reveals that the area found in Theog block measure about 48 sq. km. and Rampur block measures about 98 sq. km. By using geospatial technology suitable sites for new institutions are identified in both blocks in open and wasteland category. The study reveals that in the remaining blocks, the sites have not been found as per the given criteria. It has been observed that geospatial tools could play an important role in the planning and management of location-based services including educational infrastructure. The study also provides a better scope to address the problem while considering more appropriate decision rules and therefore can be more useful for different practical purposes. Another significant advantage of this study is the accuracy of the geospatial approach, and its simplicity, which makes the application of the geospatial technology accessible to planners.

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Geographical Perspective Vol. 26, October, 2025 ISSN 0970-809X

STRUCTURAL COMPOSITION OF HIGHER EDUCATION IN HARYANA

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ABSTRACT

In the current knowledge-based economy, higher education has gained a discernible economic significance, leading to change in the structure and dissemination of higher education. The present study aims to analyse the structural composition of higher education in Haryana on the basis of different factors such as regulatory framework, nature of education imparted by the institutions, management and location of institutions. For this purpose, secondary data has been used and analysis has been done at state and district level. In Haryana, the majority of colleges and universities focused on providing general education. Earlier, higher education sector was dominated by the public sector in the state, but with the passage of time, the private sector has taken the lead. A major share of colleges was located in rural areas, while maximum number of universities were located in urban areas. It has been observed that when the state was founded, the higher education landscape was not as diverse as it is now. Since there are many universities and colleges in the state that differ in terms of administration, the type of education they offer, and their locations, Haryana's higher education system is very unique today.

Keywords: *Structural Composition, Regulatory Framework, Nature of Education and Management of Higher Education Institutions.*

Introduction

In India, formal education is divided into three levels: primary, secondary and tertiary. Primary and secondary levels of education deal with school-based education and fall within the purview of school education. Tertiary education, often known as Higher Education, comes after secondary education. Higher education refers to the level of education that students receive while attending either a university or a college. The colonial system had an impact on how higher education has presently been structured and executed in India. However, India has a long history of advanced learning dating back to the Vedic era before the Britishers arrived. The Gurukulas served as the hubs of higher education throughout this time. The monasteries that arose throughout the Buddhist era became the centres of learning. The academic standing of the Universities of Nalanda, Vikramshila, and Vallabhi was highly renowned (Perkin,

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Economic, technological, and demographic forces are instrumental in bringing unprecedented change in India's higher education system. The government is committed to improve the higher education sector in terms of funding, leadership, accountability, global collaboration, teaching, and quality control in the coming years. However, the issue of what is actually happening in universities and colleges remains of utmost importance (Everitt, 2014).

Objectives and Methodology

The structural composition of higher education can be analyzed in many ways. For the present study it has been studied on the basis of regulatory framework, management of the institutions, nature of education imparted by institutions and their location. The regulatory framework has been same for all the states and union territories as education is the subject of concurrent list and it is managed by central as well as state governments, so it is considered and framed at country level. While the management, nature of education imparted by institutions and their location has been explored at district level for the state of Haryana. In the present research work in terms of management, institutions have been broadly categorized as under the government and private sectors. They have further been sub-categorized into different categories. On the basis of nature of education, they have been studied as general, professional and technical institutions and location of the institutions has been examined as rural and urban institutions. So, the present study deals with different aspects of structural composition of higher education in Haryana. The part of the study that deals with nature of education imparted by the institutions however, has the limitation of availability of data. As the district wise data of different types of institutions such as general, professional and technical was not available, state as a whole, has been taken into consideration for examining the general, professional and technical institutions of higher education.

Results and Discussion

In Haryana, there have been a variety of structural and conceptual impediments to the creation of a dependable higher education system. The structure of higher education in Haryana has been categorised into:

1. Colleges
2. Universities

For the present study, the structural composition of the higher education (colleges and universities) of Haryana has been studied on the following basis:

I. Regulatory Framework

II. Nature of Education imparted by institutions

III. Management of Institutions

IV. Location of Institutions

2006). In mediaeval India, the ancient centres struggled to survive in the social and political chaos brought on by the various foreign invasions. Although these organisations lost their lustre, they did not totally disappear. The Madarasas, which had become the new centres for higher education, coexisted with them. The Islamic tradition of knowledge and understanding had an impact on them. Following this time, the Britishers established India's universities and colleges, which were higher education institutions. At the start of the 20th century, there was an increase in the demand for new universities and several new universities were established (Agarwal, 2012).

At present, higher education is a shared responsibility of the central and state governments. The coordination and establishment of standards in universities and colleges is the responsibility of the University Grants Commission (UGC) and other statutory regulating agencies. The UGC acts as a vital conduit between the central and the state governments and higher education institutions. Its two primary duties are to provide funding and to make sure that higher education institutions uphold their standards. Additionally, it provides guidance to the central and state governments on how to improve university education (Malik, 2017).

India has a highly developed higher education system that provides education and training in a wide range of fields, including arts and humanities, natural, mathematical and social sciences, engineering, medicine, dentistry, agriculture, education, law, commerce and management, music and performing arts, national and foreign languages, culture, communications etc. The institutional framework comprises of various types of academic institutions, including Central Universities established by an Act of Parliament; State Universities established by a State Legislature; Deemed to be Universities which have been granted the authority to award their own degrees through central government notification; Institutes of National Importance which are prestigious institutions bestowed with this status by Parliament; Institutions established by State Legislative Act; and colleges (both government-aided and unaided) affiliated with the University (Annual Status of Higher Education (AISHE) Report, 2013). The higher education system in the country comprises of three levels of qualification:

I. Graduation level

II. Post-graduation level

III. Doctoral Level.

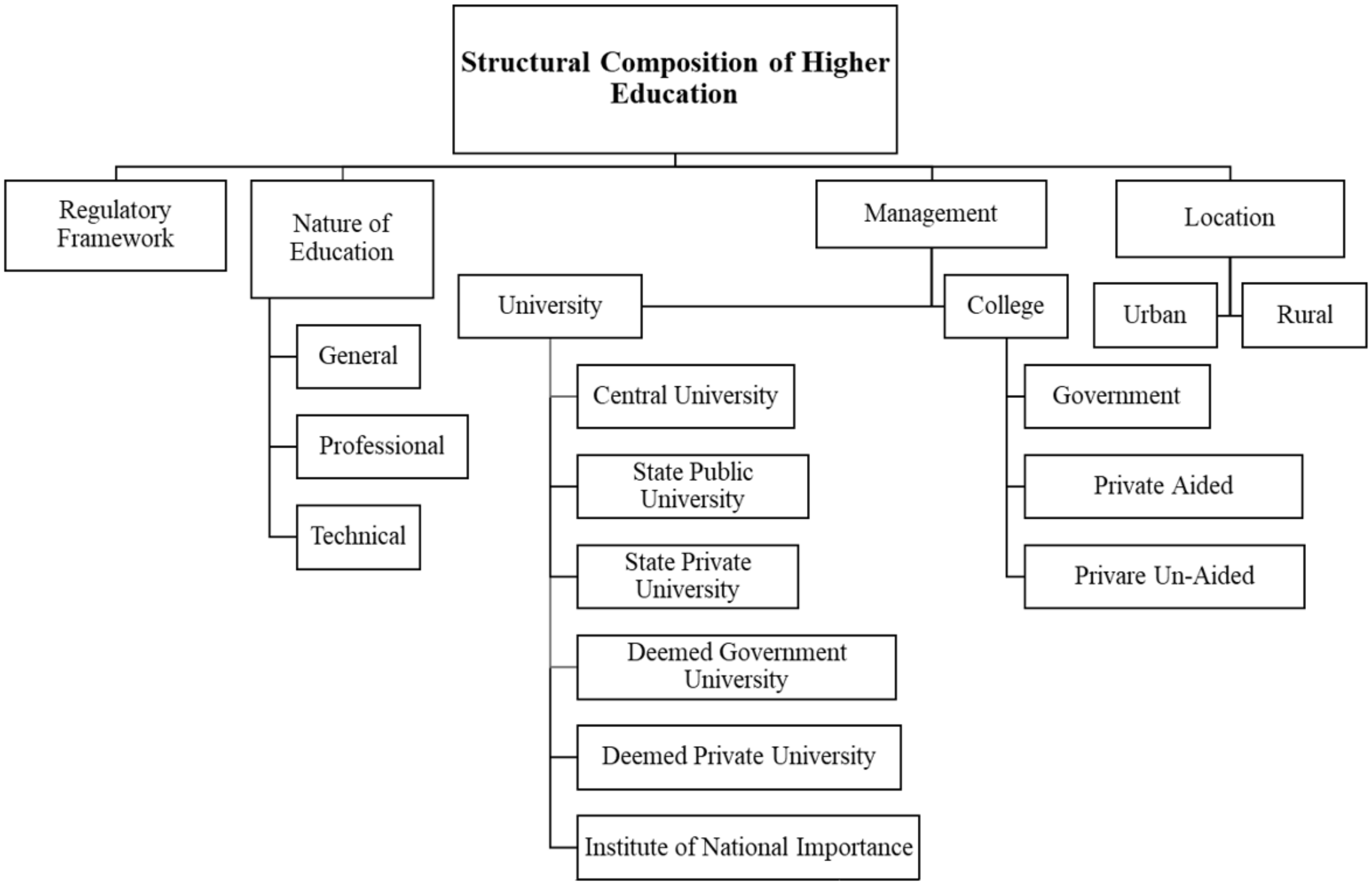
In addition to the aforementioned three qualifications, there exists another qualification known as a Diploma. This academic programme is offered at both the undergraduate and postgraduate levels. At the undergraduate level, the duration of the course can range from one to three years. Postgraduate diplomas are typically conferred upon completion of a one-year course, although certain diplomas may require two years of study (UNESCO, 2010; Kumar & Ambrish, 2015; Saxena, 2018)

Regulatory Framework

India's higher education system has a complex regulatory structure (Shah, 2015). The higher education system is governed by a multitude of agencies and a complex network of rules and regulations, with the University Grants Commission serving as the central authority. The regulatory system is primarily influenced by key stakeholders such as Professional Councils at both national and state levels, state governments and affiliating universities. The year 1976 marked the inclusion of education in the Concurrent List, thereby granting the central government an equivalent status with the states in matters pertaining to education across all levels. The Ministry of Education, formerly known as the Ministry of Human Resource Development, serves as the primary means through which the central government discharges its responsibilities. Furthermore, there exist several ministries and departments in the Government of India that are responsible for the establishment, financing or regulation of higher education institutions. The majority of state functions are carried out by the respective government departments or directorates within the states. Numerous states have established either state councils or advisory boards to oversee higher education. Overall, higher education powers in the states are centralised in higher education departments and subject to the same bureaucratic control as other branches of government (Agarwal, 2009).

At the state level, Haryana has Department of Higher Education which works under the Government of Haryana. The main objective of the department is to make Haryana a knowledge-based community and to provide access and ensure inclusion of all sections of the society. The Haryana State Higher Education Council has been constituted under the 'Haryana State Higher Education Council Act, 2018' passed by the Haryana State Legislature on February 28, 2018. The council is responsible for policy formulation and future planning and for promoting social justice while ensuring autonomy and greater accountability of all institutions of higher education in the state and for the development of higher education in accordance with the socio-economic requirements of the state as required by the Rashtriya Uchchatar Shiksha Abhiyan (RUSA) (Department of Higher Education Haryana, n.d.).

The universities that grant their own degrees are divided into six categories on the basis of their management, Central University, State Public University, State Private University, Deemed to be University (Government), Deemed to be University (Private) and Institutes of National Importance. Moreover, degrees are awarded by colleges under the name of the university to which they are affiliated. In addition to this, 15 professional councils (like Medical Council of India (MCI) and All India Council for Technical Education (AICTE)) regulate the courses run by the colleges and universities (Table 1). The University Grants Commission (UGC) serves as the over-arching regulatory body.



Source: *Annual Status of Higher Education, 2021; All India Survey on Higher Education Report 2020 and Statistical Abstract of Haryana, 2021.I. Regulatory Framework*

Figure 1: Structural Composition of Higher Education

Various regulatory bodies, like the Bar Council of India (BCI), All India Council for Technical Education (AICTE), and the Medical Council of India (MCI) among others, are responsible for managing various professional courses. There are two organisations that grant accreditation, the National Board of Accreditation (NBA), which was established by the AICTE, and the National Assessment and Accreditation Council (NAAC), which was established by the UGC. All higher education institutions must be accredited by an accreditation organisation, according to the UGC Regulations, 2012.

Universities, colleges and other institutions are examples of higher education institutions in India. Universities award their own degrees, whereas colleges award degrees through the universities with which they are affiliated. Universities can affiliate with other colleges or function unitarily. A school or a department will offer a specific course at a unitary university, whereas the college offers the courses for an affiliating university. Professional councils such as the All India Council for Technical Education (AICTE), the Medical Council of India (MCI), and others govern courses at the college and university level. Classroom education is influenced by rules and regulations at the university, college, and course levels. So, the university, college, and course are the main linkages in the sector of higher education as a whole. Each level has substantial entry, operation, and exit hurdles, therefore examining the regulatory environment at each level will provide a complete picture of the higher education landscape (Shah, 2015).

Table 1: Regulatory and Statutory Bodies in the Higher Education in India

Name of the Body and Establishment Year	Expected Functions
University Grants Commission (1956)	• Co-ordination, determination and maintenance of standards in higher education. • Release of grants to individual institutions.
All India Council for Technical Education (1945)	• Proper planning and co-ordinated development of the technical education system throughout the country.
Distance Education Council (1991)	• Promotion of Open University and Distance Education systems in the educational pattern of the country for coordination and determination of standards of teaching, evaluation and research in such systems.
Indian Council of Agricultural Research (1929)	• Co-ordination of agricultural research and development levels with related organisations to enhance the quality of life of the farming community.

Bar Council of India (1961)	• Co-ordination, determination and maintenance of standards in legal education and profession.
National Council for Teacher Education (1995)	• Achieving planned and co-ordinated development of the teacher education system throughout the country, the regulation and proper maintenance of norms and standards in teacher education and for matters connected therewith.
Rehabilitation Council of India (1993)	• Standardisation and regulation of training of personnel and professionals in the field of Rehabilitation and Special Education.
Medical Council of India (1934)	•Establishment of standards in medical education and to define medical qualifications in India and abroad
Pharmacy Council of India (1948)	• Prescription, regulation and maintenance of minimum standards for the training of pharmacists uniformly in the country.
Indian Nursing Council (1947)	• Regulation and maintenance of uniform standards of training for Nurses, Midwives, Auxiliary Nurses-Midwives and Health Visitors.
Dental Council of India (1949)	• Regulation of the Dental Education, Dental Profession, Dental ethics in the country and recommending to the Government of India to accord permission to start a Dental College, start higher courses and increase the number of seats.
Central Council of Homeopathy (1973)	• Maintenance of the Central Register of Homoeopathy.
Central Council of Indian Medicine (1971)	• Maintenance of the Central Register of Indian Medicine.

Adapted from: a. Govt. of India (2005) , Report of Central Advisory Board of Education Committee on Autonomy of Higher Education Institutions, Ministry of Human Resource Development, New Delhi b. Varghese (2015)

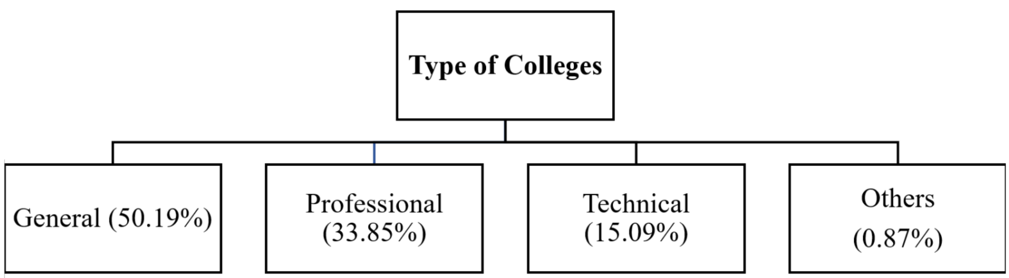
Transformation of the Regulatory Framework (National Education Policy (NEP), 2020)

The first National Policy on Education was formulated by the Government of India in 1968. It aimed to achieve the objective of harmony and integration by seeking total reformation and extending educational opportunities to all segments of society. In 1986, the Indian government initiated the second National Policy on Education. Its primary goal was to provide education to all sections of society, with a particular emphasis on scheduled castes, scheduled tribes, other marginalised classes, and women, who had been denied access to education for centuries. After the changes suggested by the Central Advisory Board of Education (CABE), this policy came to be known as the National Programme of Action of 1992. The National Programme of Action of 1992 placed significant emphasis on the necessity for extensive transformation of the Indian educational system, with a particular focus on the enhancement of quality (Ranganathan, 2007). The National Education Policy (NEP) unveiled on July 29, 2020, is the third education policy issued by the Government of India ever since the independence of the country (Chattopadhyay, 2020). To re-energize and enable the higher education industry to grow, the regulatory system needs to be completely overhauled. The higher education regulatory system will make sure that the distinct roles of regulation, accreditation, funding, and academic standard setting will be conducted by distinct, independent, and empowered authorities to handle the afore-mentioned problems. In order to establish checks and balances in the system, to reduce conflicts of interest, and to get rid of concentrations of power, this is seen as crucial (Section 18.2, NEP 2020).

Nature of Education imparted by Institutions

As per the nature of education imparted by the higher education institutions, these can be broadly categorised into three types: General, Professional and Technical. The General education mainly consists of higher education courses in arts, commerce and science. Professional education includes courses in medical education, law and other specialized fields. The Technical education on the other hand comprises of programmes of education, research and training in engineering technology, architecture, town planning, management, pharmacy and applied arts & crafts (Annual Status of Higher Education (ASHE) Report, 2013).

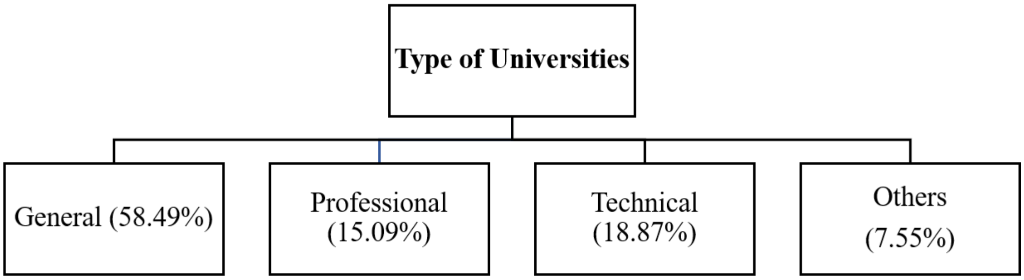
In 2019-20, the state of Haryana had 1075 colleges in total. Out of these, half of the colleges i.e. 50.19 per cent of the total colleges were providing general education, another one third i.e. 33.85 per cent colleges were offering specialisation in professional education. Moreover, 15.09 per cent of the colleges were committed to provide technical education (Fig. 2).



Source: Annual Status of Higher Education (ASHE) Report, 2021.

Figure 2 : Haryana: Type of Colleges, 2019-20

The state of Haryana had in all 53 universities, that were an admixture of varied fields. Maximum percentage of the universities i.e. 58.49 per cent was committed to provide general education. Another 18.87 per cent of the universities were offering specialisation in technical education. Furthermore 15.09 per cent of the universities were working to provide professional education (Fig. 3).



Source: *Annual Status of Higher Education (ASHE) Report, 2021.*

Figure 3: Haryana: Type of Universities, 2019-20

Management of Institutions

The Establishment Act of the legislature and the system of financing higher education closely follow the type of management of the institution. The success of any educational institution depends on many components, namely management, staff and students. The management has a very important role to play. The management of the colleges and universities has been discussed in the paragraphs given below:

Management of Colleges

As per the management, colleges can be broadly categorised into two types: Government and Private. Further, there are two types of private colleges: aided and un-aided. The aided colleges are supposed to get up to 95 per cent of the teachers' salary bill reimbursed. The un-aided ones have no access to government funds and they run their colleges on higher tuition fees as well as grants/donations (Kaul, 2006). In the state of Haryana, maximum share of colleges was managed by the private sector. Further, in the private sector maximum share was dominated by the un-aided colleges. Almost 71 per cent of colleges came under un-aided umbrella. After that, second highest share was of Government colleges followed by the aided colleges (Fig. 4). Further, un-aided colleges were almost six times more than the aided colleges and four times more than the Government colleges.

The top three districts with highest number of un-aided colleges were Sonipat, Mahendragarh and Gurugram. In terms of aided colleges, the highest number of aided colleges were reported in Rohtak, Sonipat and Yamunanagar. The highest number of Government colleges was registered in Hisar and Mahendragarh followed by Rohtak and Rewari (Table 2).

Table 2: Haryana: Type of Colleges on the basis of Management, 2019-20

Sr. No.	Districts	Government	Aided	Un-Aided	Total
1	Ambala	5	9	28	42
2	Bhiwani	10	6	32	48
3	Charkhi Dadri	3	5	15	23
4	Faridabad	8	6	39	53
5	Fatehabad	6	1	19	26
6	Gurugram	8	2	57	67
7	Hisar	16	6	46	68
8	Jhajjar	14	4	48	66
9	Jind	10	3	30	43
10	Kaithal	4	7	19	30
11	Karnal	10	5	31	46
12	Kurukshetra	7	7	30	44
13	Mahendragarh	16	7	60	83
14	Nuh	6	2	6	14
15	Palwal	5	2	24	31
16	Panchkula	6	1	15	22
17	Panipat	4	5	32	41
18	Rewari	11	6	30	47
19	Rohtak	15	19	53	87
20	Sirsa	8	6	31	45
21	Sonipat	9	11	70	90
22	Yamunanagar	3	10	46	59
	Haryana	**184**	**130**	**761**	**1075**

Source: All India Survey on Higher Education, 2019-20.

Source: *Based on Table 2*

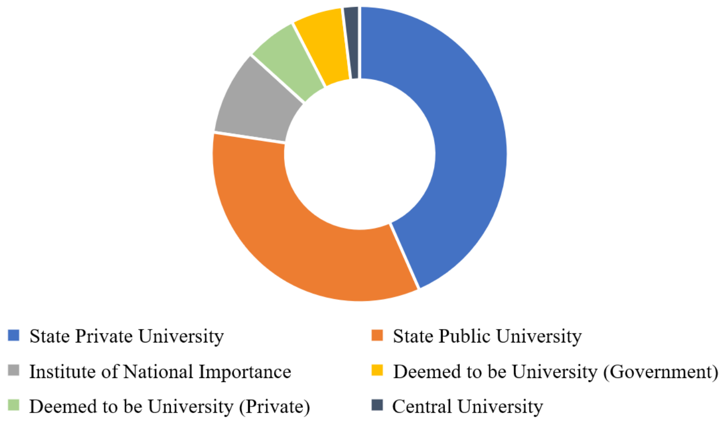
Figure 4 : Haryana : Type of Colleges on the basis of Management 2019-20

Colleges cannot grant degrees directly. They are affiliated with some university which has the authority to grant degrees to the students. Those colleges which work in accordance with the rules and regulations of such university to which they are affiliated with, are called affiliated colleges (All India Survey on Higher Education (AISHE) Report, 2020). In Haryana, 97.40 per cent of the total colleges were affiliated colleges. Further, university/constituent colleges are maintained by the university. The share of such colleges in Haryana was 2.51 per cent of the total colleges. On the other hand, there were also found Recognised Centres, these can be defined as institutions attached with the university for the purpose of awarding degree in respect of the programmes being run in these institutions. Their share in the state was very negligible i.e. only 0.09 per cent (All India Survey on Higher Education (AISHE) Report, 2020).

Management of Universities:

As per the management, universities can be further divided into many types i.e., Central Universities, State Universities, Private Universities, Deemed-to-be Universities and Institutes of National Importance. In Haryana, universities are located in 16 districts out of 22 and the remaining six districts have no university at all. As found that, most of the universities came into being after the year 2000. In 2019-20, Haryana had total 53 universities and out of these 23 universities were state private universities (Table 3). As many as 18 universities were state public universities, which were followed by institute of national importance, deemed to be universities government and private and a central university. The state had equal number of deemed to be university (government) and deemed to be university (Private) i.e. 3 each. Haryana has only one Central University which is located in Mahendragarh district of Haryana (Table 3).

Further, Gurugram district had the highest number of universities, followed by Sonipat and Faridabad. Hisar and Kurukshetra had the same number of universities i.e. 4 each. While seven districts such as Bhiwani, Jind, Kaithal, Karnal, Mahendragarh, Rewari and Sirsa had only one university each. All the deemed to be universities were to be found in the districts of National Capital Region (NCR), with the only exception of one in Ambala.



Source: *Based on Table 3*

Figure 3: Type of Universities on the basis of Management, 2019-2020

Table 3: Haryana: Type of Universities on the basis of Management, 2019 -2020

Sr. No.	Districts	Central University	State Public University	State Private University	Deemed to be University (Government)	Deemed to be University (Private)	Institute of National Importance	Total
1	Ambala	0	0	1	0	1	0	2
2	Bhiwani	0	1	0	0	0	0	1
3	Faridabad	0	1	2	0	2	1	6
4	Gurugram	0	1	10	1	0	0	12
5	Hisar	0	3	1	0	0	0	4
6	Jhajjar	0	0	2	0	0	0	2
7	Jind	0	1	0	0	0	0	1
8	Kaithal	0	0	1	0	0	0	1
9	Karnal	0	0	0	1	0	0	1
10	Kurukshetra	0	2	0	0	0	2	4
11	Mahendragarh	1	0	0	0	0	0	1
12	Palwal	0	1	1	0	0	0	2
13	Rewari	0	1	0	0	0	0	1
14	Rohtak	0	3	1	0	0	1	5
15	Sirsa	0	1	0	0	0	0	1
16	Sonipat	0	3	4	1	0	1	9
	Haryana	**1**	**18**	**23**	**3**	**3**	**5**	**53**

Source: All India Survey on Higher Education (AISHE), 2019-20.

Location of Institutions

The location of an educational institution is of tremendous importance. If it is easily accessible, it would draw students from all directions. It has to be well connected, so that commuting through public transport is possible. It should be situated in a well-populated area. On the basis of location higher education institutions can be divided into rural and urban.

Location of Colleges:

As per the location of the institutions, more than two thirds (68 per cent) of the total colleges were located in rural areas. The highest number of rural colleges were found in Mahendragarh (64) district which was followed by Hisar, Jhajjar and Gurugram. The colleges located in urban areas constituted 32 per cent of the total colleges (Table 4). Rohtak district had highest number of urban colleges followed by Sonipat and Faridabad. Out of the total population in the age group of 18-23 years, 65.47 per cent reside in rural areas of the state. It has been observed that the districts, which had higher share of colleges in rural areas also had the higher share of rural population in the age group of 18-23 years.

Table 4: Haryana: Rural-Urban Distribution of Colleges, 2019-20

Sr. No.	Districts	Number of Colleges (Rural Areas)	Number of Colleges (Urban Areas)	Total Number of Higher Education Institutions
1	Ambala	28 (66.67)	14 (33.33)	42
2	Bhiwani	32 (66.67)	16 (33.33)	48
3	Charkhi Dadri	17 (73.91)	6 (26.09)	23
4	Faridabad	30 (56.60)	23 (43.40)	53
5	Fatehabad	22 (84.62)	4 (15.38)	26
6	Gurugram	47 (70.15)	20 (29.85)	67
7	Hisar	50 (73.53)	18 (26.47)	68
8	Jhajjar	48 (72.73)	18 (27.27)	66
9	Jind	27 (62.79)	16 (37.21)	43
10	Kaithal	20 (66.67)	10 (33.33)	30
11	Karnal	32 (69.57)	14 (30.43)	46
12	Kurukshetra	31 (70.45)	13 (29.55)	44
13	Mahendragarh	64 (77.11)	19 (22.89)	83
14	Nuh	12 (85.71)	2 (14.29)	14
15	Palwal	26 (83.87)	5 (16.13)	31
16	Panchkula	18 (81.82)	4 (18.18)	22
17	Panipat	35 (85.37)	6 (14.63)	41
18	Rewari	39 (82.98)	8 (17.02)	47
19	Rohtak	40 (45.98)	47 (54.02)	87
20	Sirsa	28 (62.22)	17 (37.78)	45
21	Sonipat	45 (50.00)	45 (50.00)	90
22	Yamunanagar	40 (67.80)	19 (32.20)	59
	Total	**731 (68)**	**344 (32)**	**1075**

Source: All India Survey on Higher Education (AISHE), 2019-20.
Note: Figures in parentheses indicate percentage.

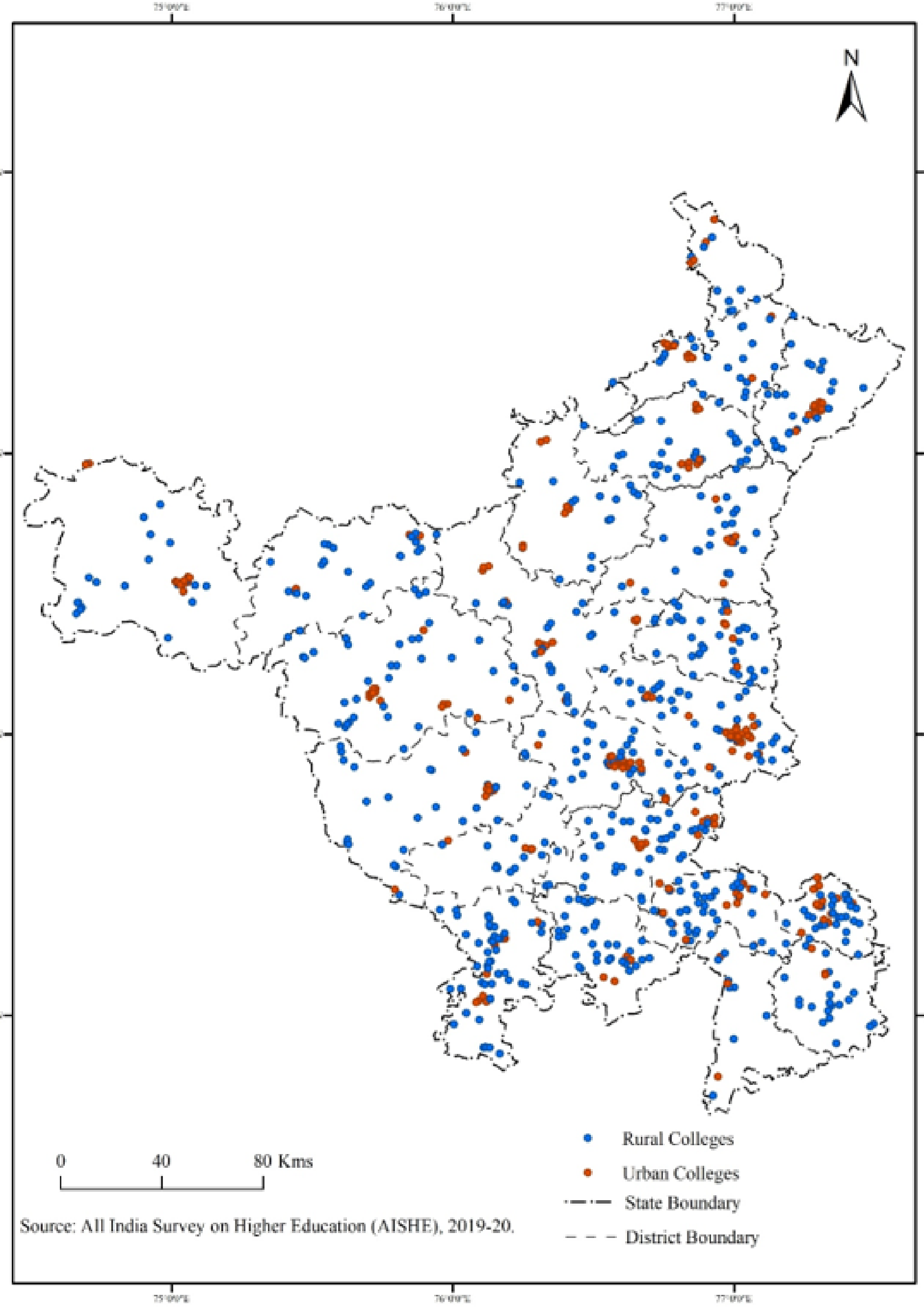


Figure 6 : Location of Colleges in Haryana (District wise)

Location of Universities:

In the year 2019-20, more than one third (37.74 per cent) of the total universities were located in rural areas (Table 5). On the whole, Gurugram (12) had the highest number of universities and in terms of distribution of the universities in rural areas, Gurugram (5) again topped in the list of districts and it was followed by Sonipat (4). On the contrary, Bhiwani, Jind, Karnal and Sirsa had no university in rural areas. In case of urban universities, the highest number was found again in Gurugram district (7) which was followed by Faridabad (5) and Sonipat (5). The four districts of Kaithal, Mahendragarh, Palwal and Rewari had no university in urban areas.

Kurukshetra University, established in Kurukshetra city in 1956, was the first and oldest state public university of Haryana, followed by Chaudhary Charan Singh Haryana Agricultural University which was established in Hisar city in 1970 and Maharshi Dayanand University in Rohtak city in 1976 was also established in urban area. In 2019-20, 83.33 per cent of the total state public universities were located in urban areas of the state. 43.48 per cent of the state private universities were located in urban areas. All the deemed to be universities (government and private) except one were found in urban areas. The Central University of Haryana was established in 2009 and located in Jant Pali villages of Mahendragarh.

Table 5: Haryana: Rural-Urban Distribution of Universities, 2019-20

Sr. No.	Districts	Number of Universities (Rural Areas)	Number of Universities (Urban Areas)	Total
1	Ambala	1 (50)	1 (50)	2
2	Bhiwani*	0 (0)	1 (100)	1
3	Faridabad	1 (16.67)	5 (83.33)	6
4	Gurugram	5 (41.67)	7 (58.33)	12
5	Hisar	1 (25)	3 (75)	4
6	Jhajjar	1 (50)	1 (50)	2
7	Jind*	0 (0)	1 (100)	1
8	Kaithal**	1 (100)	0 (0)	1
9	Karnal*	0 (0)	1 (100)	1
10	Kurukshetra	1 (25)	3 (75)	4
11	Mahendragarh**	1 (100)	0 (0)	1
12	Palwal**	2 (100)	0 (0)	2
13	Rewari	1 (100)	0 (0)	1
14	Rohtak	1 (20)	4 (80)	5
15	Sirsa*	0 (0)	1 (100)	1
16	Sonipat	4 (44.44)	5 (55.56)	9
	Haryana	**20 (37.74)**	**33 (62.26)**	**53**

Source: All India Survey on Higher Education (AISHE), 2019-20. Available at https://aishe.nic.in/aishe/dataUserReportHome Note: Figures in parentheses indicate percentage.

*: No University in rural areas **: No University in urban areas

The higher number of universities, which were located in urban area are found in Gurugram, Faridabad, Sonipat and Rohtak and all of these four districts also had relatively higher number of urban population in the age group of 18-23 years (Census 2011). The reason that four districts of the state namely Kaithal, Mahendragarh, Palwal and Rewari, did not have any university in urban areas, might be the least share of urban population in the age group of 18-23 years.

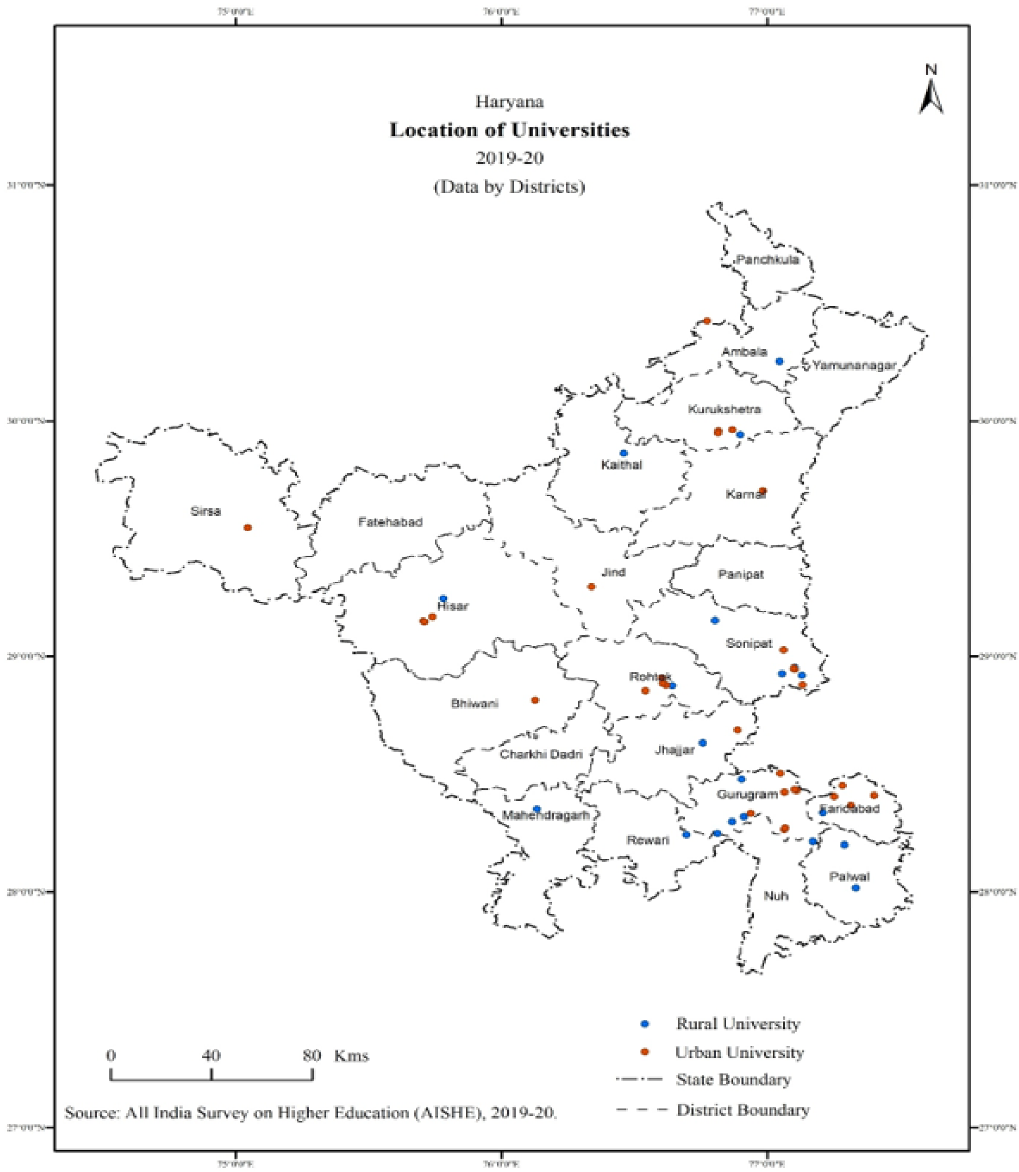


Figure 7 : Location of University in Haryana

Conclusion

As discussed above, India's higher education system is quite complex. The Ministry of Education regulates education in the country at the national level. Similarly, at the state level, the Department of Higher Education is in charge of higher education. Haryana is no exception to this. It provides higher education at the university and college levels where Colleges are affiliated to the universities, which are linked to regulatory organisations. The National Education Policy (NEP), released on July 29, 2020, is India's third education policy since independence. According to this, the regulatory framework must be changed to revitalise and grow higher education.

Therefore, the ongoing discussion revealed that, at the time of the state's inception, the higher education sector was not as diverse as it is today. Haryana's higher education structure is extremely distinct today, since the state contains a multitude of universities and colleges in terms of management, nature of education delivered, and location. Previously, the majority of colleges and universities operated within the public sector. However, as time progressed, various kinds of institutions emerged in the state to fulfil the demands of today's knowledge-based economy.

The higher education policies of Haryana state focus on accessibility, quality, equity, and future-readiness and are in alignment with New Education Policy 2020. To serve the diverse learners need, the policy framework encourages the development of interdisciplinary approaches and the establishment of flexible learning pathways. The key initiatives taken by the state are to provide free higher education to female students from economically weaker sections, which help in promoting gender equity in the sector, and the integration of the National Credit Framework to enable seamless academic progression across various educational levels. The Directorate of Higher Education and the Haryana State Higher Education Council work together to provide strategic planning and governance in the sector, and they are responsible for overseeing the proper implementation of these strategies.

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CHARACTERISTICS OF "SAVE HILL" MOVEMENT AND SPATIAL SIGNIFICANCE OF PEOPLE'S STRUGGLE: A CASE STUDY OF KAJURA GRAM PANCHAYAT REGION OF RAGHUNATHPUR-I BLOCK OF PURULIA DISTRICT, WEST BENGAL

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ABSTRACT

The concepts of space and place have distinct political dimensions. Different socioeconomic and political reasons are mainly responsible for the development of public mobilization and different patterns of mass protest in many parts of the world. Dialectics of political space and its political outcome are influenced by spatial reasons embedded within its cultural space. In this paper, an attempt has been made to explain the socioeconomic and political dynamics of the "Save Hill" movement (from January 2016 to March 2016) in Senara village of Kajura Gram panchayat region of Purulia district, India, and its relationship with components of space. This entire paper is developed on the basis of intensive fieldwork, household surveys, and interviews to analyze the identification of spatial characteristics of different patterns of protest movement of local people. This paper also intends to establish a spatial dynamic of political actions and its influence on local political and social movements.

Keywords: Ukharidanga stone project, "Dungri" and "patharchattan", "Majhi-Pargana-Disam" system, PPP model.

Introduction

Different types of physical spatial expressions are recognized as spatial religious and cultural symbols of different communities, particularly among the indigenous communities all over the world. Small residual hills with their vegetative cover are designated as sacred space for local tribal and indigenous communities of Purulia, India. If this protected place is attacked due to political disturbances, if the comforts of "inside" are threatened by political forces, what will be the human response? The answer lies in the formation and development of social/socio-political movements, and their vivid academic discussion is needed.

During the 19th and 20th centuries, the majority of socio-political movements were economy-centric, which means that the majority of these movements specialised in placing Economic

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demands, and cultural, environmental, ethnic, and gender aspects were ignored. Sociologist Georg Simmel (1997), in his book "The Sociology of Space," discusses five aspects of space, such as i) “exclusivity”, ii) “boundaries of space”, iii) “fixity of social forms in space”, iv) “spatial proximity and distance”, and v) “mobility in space”. According to Lefebvre, socio-spatial dialectic is the main driving force behind the survival of capitalism. As he wrote, “Capitalism has found itself able to attenuate its internal contradictions for a century and consequently in the hundred years since the writing of Capital”, it has succeeded in achieving growth. We cannot calculate at what price, but we do know the means: **by occupying space, by producing space** (Soja, 2001). At this point, I want to draw attention to the words of Lefebvre, “by occupying space, by producing space”, which are the driving force for the evolutionary development of socio-political movement. **Lefebvre** also analyses that the space is an important analytical tool to uncover the mysteries of spatial components through elaborate discursion of “spatial practice”, “representation of space and representational space” (Zieleniec, 2007). Georg Simmel extensively discussed about space in his book “The Sociology of Space” the identification of five categories of space such as “(1) exclusivity (2) boundaries of space (3) fixing of social forms in space (4) spatial proximity and distance and (5) mobility in space…….” (Zieleniec, 2007). Apart from space, the connotation of place and displacement are important aspects of geographical knowledge. According to Yi Fu Tuan, place represents human emotions, attachments, anger, and Behavioural values. The concept of “Topophillia” and “topophobia” was introduced by Tuan and is essential for the construction of an eco-humanistic structure of a geographical space, where Tuan wrote, “Interest in place and in the meaning of place is universal”. The academic discipline that studies place is geography. Geographers have approached the study of place from two main perspectives: “place as location, a unit within a hierarchy of units in space, and as unique artefact” (Tuan, 1974). Tuan also pointed out the experiences of human beings through which he/she interact with the “work world”. Actually, components of human experiences with “taste, smell, and touch” (Ibid.) act as a bridge between their “life world” and “work world”. Tuan identified several components of place, which are as follows: 1. Home/"places within home” 2. City; 3. Region 4. Nation State (Ibid.). Tuan then correlates between place 7 politics; as he said, “Politics creates place by making it visible”. Home is a place. The family is the smallest political unit. Its form of government is traditionally authoritarian. Home has boundaries that need to be defended against the intrusion of outsiders. Home is a place because it encloses space and thereby creates an “inside” and an “outside”.The more the storm rages outside, the cozier the home feels inside, the more family is united, and the more the home itself is a unit, not an arrangement of separate rooms (Ibid.). Foucault (1980) examined whether popular justice was really served in both developed and developing countries. He also emphasizes the inclusion of “place” in archaeology of geographical knowledge (Foucault, 1980). According to Mahato (2015), there were a few indigenous land tenure/revenue systems found in the

Jungle Mahal region during the pre-colonial era, but they were gradually destroyed by British imperialism during the colonial era. Anthropologist Mahato, P. P. (2012), identified the cultural mindset of indigenous and tribal communities of the greater Janglemahal region of West Bengal. He also pointed out the impact of both colonial and postcolonial socio-economic impacts on the indigenous communities of Bankura, Purulia, and West Medinipur districts. Pashupati Babu (Mahato, P. P., 2012) extensively investigated the power of folklore on the political theoretical frameworks of resistance of indigenous communities. Mitchell (2000) discussed the importance of spatial cultural components in the process of political mobilisation. Subjective components may have played a very important role in mobilising objective components through the agency of "New Democracy" (Mao Tse Tung, 1999). There is a close relationship between social movements and electoral politics (Mukhopadhyay, 2014a). Frank and Fuentes (2002) discussed the temporal and spatial significance. Save hill movements mainly concentrated at Barrah gram panchayat region of Kashipur C.D. block of the same district in 2015 played a very significant role in the forthcoming assembly election of West Bengal, emphasising both significant political orientation and its complex relation with religious/ traditional land use outlook (Mukhopadhyay and Jana, 2021).

This paper is quite different from previous works:

1. The nature of the "Save Hill" movement in Kajura region is exclusive due to the only participation of tribal people, particularly the overwhelming participation of the Santal community.

2. Through our investigation, it is evident the "Save Hill" movement in Kajura is temporally shortest in nature, originated in January 2016 and suddenly ended in March 2016 after the Govt. of West Bengal agreed to stop the proposed PPP model of the large stone mine project at Kuilatola sub mouza of Senara mouza of Kajura due to some electoral political reasons.

3. The Santal-dominated "Save Hill" movement of Kajura indicates that the main motivation of this social movement in Kajura is spiritual spatial type with their relationship of spiritual significance of "Sarna dharma" with spatial components. This study investigates the connection between space and place attachment with political social movements in Kajura GP region and analyzes the spatial significance of residual hills, and explores the "Save Hill" movement's exclusivity.

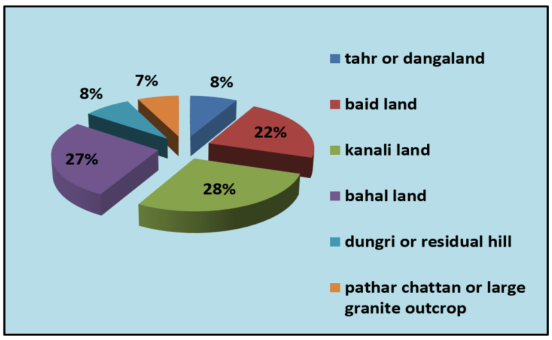


Figure 1: Different Categories of Land Surface at Kajura G.P. Purulia

Data Base and Methodology

Study Area

The Geomorphologically entire Kajura region is a peneplain with signs of multiple erosion cycles. This region is composed of small residual hills, namely Kuilatola, Ukharidanga, etc. The entire Kajura region is an undulating plain with its general slope from north-west to south-east. We found different categories of physical land surfaces all over this gram panchayat region, as shown below (Fig. 2)

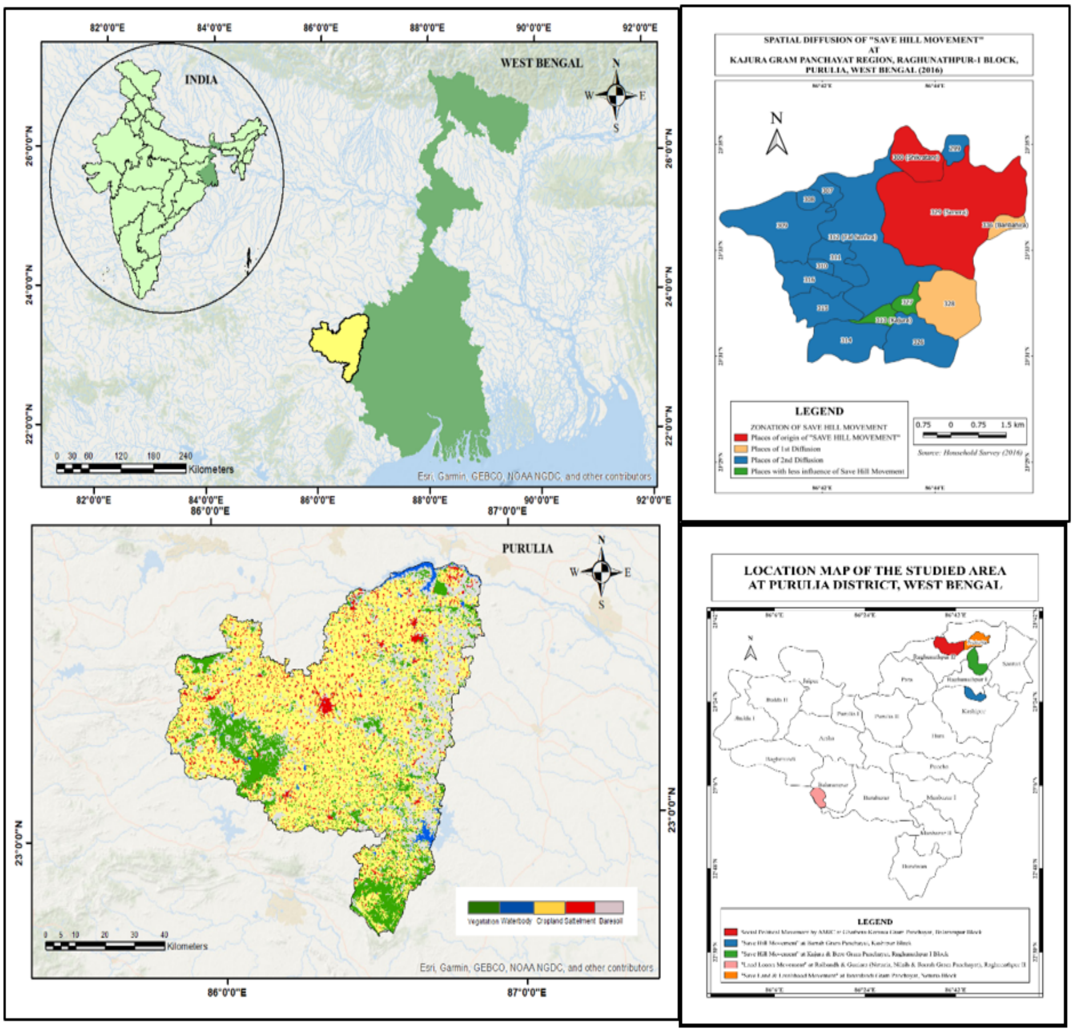


Figure 2: Study Area

Database and Methodology

This paper is mainly developed by primary data which is comprised with individual interviews, group interviews, and household survey. Household survey was conduct on the basis of sample method (social cluster method). Use of mouza maps, Google Earth images 2003 and 2019 for change detection analysis, Google Earth Pro. Sample households are selected on the basis of social cluster method as shown below:

Table 1: Total no of sample households of all diffused zones of Save "Kuilatola hill" movement at Kajura Gram Panchayat region

Name of the zones of diffusion of Save Kuilatola hill movement	Sample households (on the basis of social cluster)					
	SC	ST	OBC-B	HC	Total	%of total families of each zone
1. Places of origin (excluding the Kuilatola sub-mouza)	64	23	40	02	129	15.58% (out of the total no of families=828
2. Places of 1st diffusion	56	20	29	44	149	15.57%% (out of the total no of families=957
3. Places of the 2nd diffusion	99	49	41	26	215	15.81% (out of the total no of families=1360)
4. Places of no effect of the save hill movement	15	-	43	19	77	20.10% (out of the total no of families=383)
Grand total =	234	92	153	91	570	16.16% (out of the total no of households at Kajura G.P. 3528)

Source: Field Survey in Dec. 2017 and Nov.2018

Results and Discussions

Effects of the Ukharidanga Stone Project

There are some small stone mines in Kajura, and they are locally owned. During 1998-99, the first stone mine project was developed on Ukharidanga Pahar of Kajura Mouza under the banner of the PPP model. This private company, named "Modi Enterprises Company Ltd." of Ranchi, formed the "Kajura" stone mine project as a joint venture with the Govt of West Bengal. We visited these places five times and saw devastating effects on the local environment. Local inhabitants of Ukharidanga sub mouza of Kajura mouza have shown their fear with anxiety, but very few of them expressed it freely. The majority of inhabitants of Ukharidanga sub mouza are from SC communities, mainly from Bauri and Ruidas sub-castes.

It is already informed that one large stone mine project was developed on Ukharidanga Pahar, or the hill of Ukharidanga sub mouza of Kajura village of Kajura gram panchayat region, in the year 1999-2000 as a joint venture project with an equal partnership of the Govt. of West Bengal and B.N. Modi enterprises of Ranchi, Jharkhand, as designated as the 1st PPP model in the stone mines sector. Various stones are mainly used in the housing sector. It is well known to us that in the last two decades, from 1991 to 2011, there was tremendous growth in the housing sector in our country. As a result of this, there are tremendous demands for different types of stones still now, as also seen in the last twenty years. Due to this very high demand, the requirement of large stone mines and their construction has been accelerated in the last twenty years. During the late 1990s, peneplain regions with few residual hills of Purulia were the potential sites for this newly developed political economy. In 1998, the Govt of West Bengal initiated a master plan to develop large stone mines over residual hills in numerous places of Purulia, and the outcome of the plan was the "Kajura stone mine project" over Ukharidanga hill at Kajura mouza. We found a detailed project report on mine plan with an EIA report on the website, and visited the sites numerous times. Our field experiences are quite different from the proposed EIA report on the Ukharidanga project, as shown in the photographs above. Our findings on (based on numerous field visits to that area with a household survey based on the social cluster method) Ukharidanga Hill stone mines projects are as follows:

- Gradual destruction of the residual hill of Ukharidanga (as identified from the data of our field visit)
- No employment generation (both in the formal and informal sectors) for local people as shown below:

Table 2: Nature of workforce in the Ukharidanga stone mine project

Nature of workers	No of workers	Places of origin of workers/ from where? No in the bracket
1. manual workers	20	a) Jharkhand (16) b) Orissa (04)
2. welders/ mechanics	09	All from Jharkhand
3. Loaders	15	All from Jharkhand
4 canteen staff	06	All from Jharkhand
5. project cashiers, accountant, clerks	05	a) Jharkhand (03), b) West Bengal (01 - from North 24 pargana {Habra}) c) Orissa (01)
6. truck/ crane drivers	10	All from Jharkhand
7. technical staff	09	a) Jharkhand (08), b) Bihar (01)
8. diploma engineers	05	All from Jharkhand
9. maintenance staff	02	All from Jharkhand
10. security guard	04	All from Jharkhand
11. Managerial staff.	04	All from Jharkhand
Total	89	From Jharkhand = 83, from Orissa = 04, from Bihar =01, from West Bengal =01

Source: Data collected through the field survey on November 2016 and October 2017

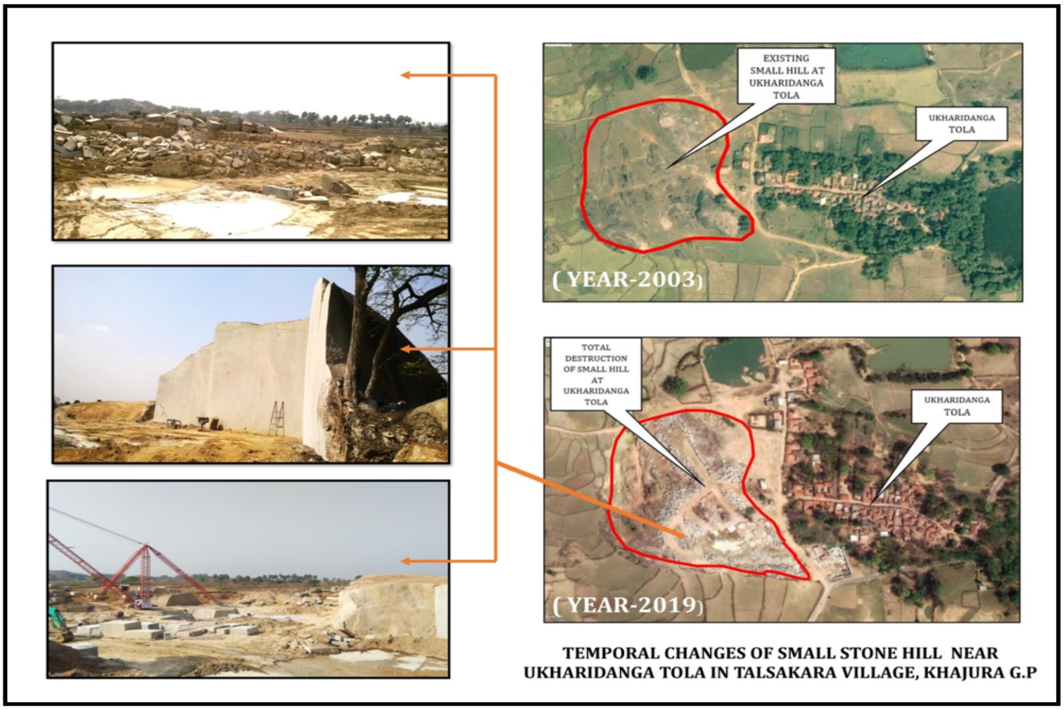


Figure 3: Temporal change of Small Stone Hill Near Ukharidanga Tola in Talskara Village, Kajura, G.P (month of January 2003 and month of February 2019).

It is evident from the above-mentioned Fig. 3 that the evolution of destruction of the residual hill of Ukharidanga from 2003 to 2019, with field experiences expressed through photographs of this specific hill from time to time.

Genesis of the Save Hill Movement at Kajura Gram Panchayat Region

The origin of the "Save Hill" movement ("Save Kuilatola Pahar Committee", or SKPC) in Kajura Gram Panchayat region was at Kuilatola sub-mouza of Senara mouza, located at the south-eastern portion of this Gram Panchayat region. The Save Hill movement was first developed at Kuilatola sub-mouza and gradually spread to other parts of this Gram Panchayat region.

"Save Hill" movement of Kajura was spread all over Kajura within a short period of time. The diffusion structure of the "Save Hill" movement of Kajura is classified with the following spatial diffusion structure:

1. Places of core origin of the "Save Hill" movement of Kajura-Kuilatola sub mouza of Senara village.

2. Places of origin of the "Save Hill" movement of Kajura region: two villages, namely Senara (Santal population = 17.22%) and Shikrataur (Santal population = 20.85%).
3. Places of 1st diffusion of the "Save Hill" movement: two villages, namely Bonbohira (Santal population = 16.67%) and Madhutati (Santal population = 13.5%).
4. Places of 2nd diffusion of "Save Hill Movement": six villages, namely Digtala (Santal population = 84.71%), Digardi (Santal population = 94.74%), Bundla (Santal population = 20.74%), Chinpina (absence of Santal population), Talsakra (Santal population = 25.72%), and UpparSakra (Santal population = 16.23%).
5. Places with no effects of "Save Hill" movement of Kajura region one village, namely Kajura (absence of Santal population).

Why People of Kuilatola Suddenly Engaged to Protest Against Proposed Stone Mine Project ("Senara Stone Mine Project") on "Kuilatola Pahar" (Residual Hill)?

In Kuilatola, our field-based household survey has three significant components: 1) an intensive household survey; 2) structured interviews with 20 participants of the "Save Hill" movement of Kajura region; and 3) a focused interview with the leader of the movement, Sri Kanuram Soren Majhi, of Kuilatola sub-mouza. The entire field work was done in November 2017, October 2018, and October 2019. As per the results of household surveys and interviews, it was found that movement suddenly surfaced when the Govt of West Bengal tied up with the private corporate sector to develop a large stone mine project over Kuilatola residual hills in December 2015 under a proposed project named "Senara stone mine project". Kuilatola Hilly Sub-Mouza is the dwelling space of 100 varieties of both plant and animal species. But unfortunately, both the EIA and DPR of this project hardly highlighted these matters. On the other hand, this report hardly mentioned the impact of this megaproject on this hill and its surroundings. Totally destroyed, Ukharidanga hill is located near the vicinity of Kuilatola, so people of Kuilatola experienced the destruction of this geomorphic feature daily and directly felt their consequences. In every interview and household survey we recorded similar facts and experiences shared by people of Kuilatola, and the most striking fact is that people complained that due to the destruction of forest cover in and around both Ukharidanga hill and village, they have experienced the situation of less rain and drought-like features in the last ten years ("okhane pathar khadan hober pore je ei khane bristi kome gelo" {due to the construction of stone mine projects, the amount of rainfall is decreased here}). We don't have any weather records specific to Senara and Kajura village, but there is a strong public perception about the hidden relationship between the construction of a stone mine project over the "Ukharidanga hills and a decrease in rainfall all over Kajura. When we asked why people of Kuilatola suddenly engaged to protest and organized the “Save Kuilatola Pahar” movement, not only over Kuilatola but all over Kajura, responses were as follows:

1a) 100% of Santal families firmly believe that Kuilatola Pahar is a dwelling place of “Marang Buru” (the great supreme spirit of “Sarna Dharma”).

2a) 100% of Santal households felt that operational works of the stone mine project may hamper several grasses and weed-covered “pathar chattan” or granite outcrops, as these are symbols of “Buru Bonga” (other hill deities/spirits) and "majhi harem” (ancestral spirit of the 1st “Majhi” of Kuilatola). Santals of Kuilatola also believe that the forest-covered Kuilatola hill (mainly "Sal," "Mahua,” and “Kul” trees, etc., are recognized as sacred groves in “Sarna dharma”) is the dwelling place of “Jaher Ayo” (the mother deity of sacred groves).

3a) 100% of SC households of Kuilatola (Dom and Paramanik families) are supportive towards the movement because they felt that the large stone mine project at Ukharidanga didn't create any jobs (formal or informal) for the local labor market ("okhane pathar katar kam paeyni keoi, emon ki Ukharidanga kono beta e pay ni" {nobody got jobs, even jobs of stone cutting at the Ukharidanga stone project, even young people of Ukharidanga didn't get jobs there}). So, what is the use of the Kuilatola stone mine project?

4a) All families of Kuilatola said that different types of pollution, such as air pollution, water pollution, and noise pollution, of the existing stone mine project in nearby Ukharidanga have made their lives miserable in the last ten years, so they are not willing to aggravate all types of pollution by permitting the proposed Kuilatola project. Due to these reasons, they are active in organizing against this proposed project.

b) Whether the principle of “Sarna dharma” has influenced the mass psychology of the movement?

Positive opinions are also observed in Kuilatola, particularly among Santal households. Similar views are also observed among SC communities, with few exceptions. It is seen in the table below:

How was the Save Hill movement spread from Kuilatola sub-mouza to all over Kajura?

Before starting the discussion of this part, we would suggest that we should be aware of the Santal social, political, and religious organisation in brief. As an indigenous community, the Santal community has a distinct decentralised social, political, and religious organisation, as termed the “**Majhi-Pargana-Disam system”** by Sri Kanuram Soren, leader of the “Save Hill” movement of Kajura. Now we discuss the basic structure of the Santal social political organization or “*Majhi-Pargana-Disam system”* which is as follows:

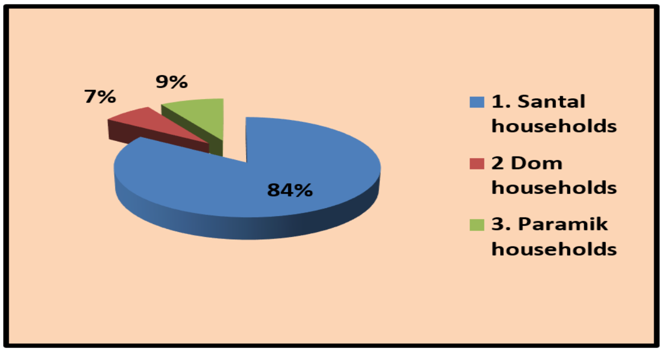


Figure 4: Ethnic Composition of Kuilatola Sub Mouza, Senara Mouza, Kajura G.P

Structure of "Majhi-Pargana-Disham System

1st tier: Traditional village council is mainly composed of one Santal majority or exclusive Santal village. This traditional village council is termed as "Majhi" or "More-Hore-Kho" in Santali language. Administratively this "Majhi" system is developed with specific ***communal-social rural grass root leadership*** associated with village council in which all head of the Santal families of that particular village are the members of that council. This council is governed by some communal social officials who are termed as officials of "Majhi system" as shown in the line diagram below;

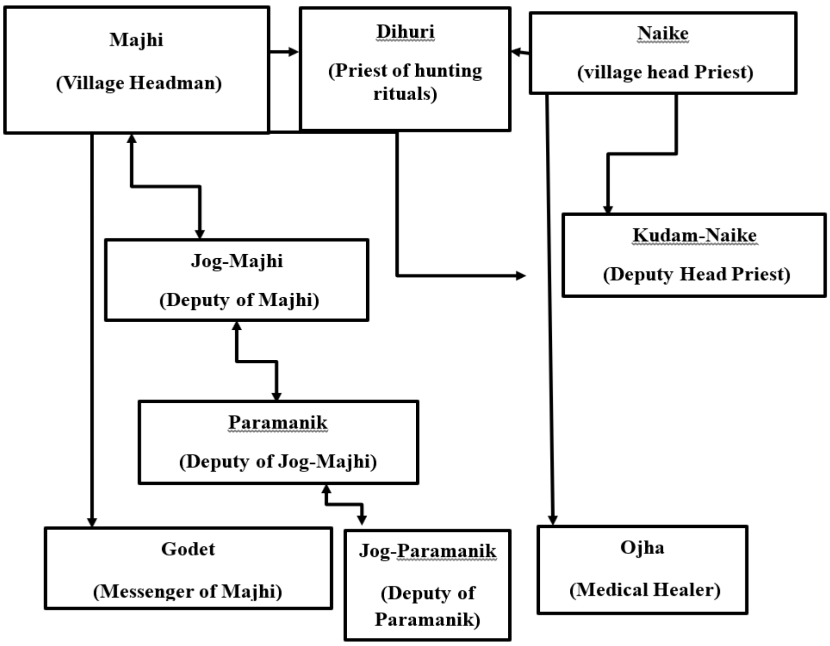


Figure 5 : Structure of "Majhi" system in a Santal dominated village

Duties of the Santal traditional village council are guided by the principles of "Sarna Dharma". The main communal and social works of the Majhi system are as follows:

A. All the communal and social posts are reserved for males of Santal families.

B. All decisions are taken through continuous paths of negotiations with debate, and finally with unanimous decisions, and carried out by all other officials under the village headman's council.

C. The "Majhi" system tries to resolve internal civil disputes among Santal villages.

D. The "Majhi" system is involved with two important cultural events, namely a) the mountain ritual, or "Buru Bonga" ritual system, and b) the hunting ritual, or "Sendra Bonga" cultural rituals.

E. All the cultural rituals are associated with two aspects, namely different natural habitats such as forests, hills, sacred groves, sacred water bodies, and communal ownership over these habitats.

F. The 'Majhi" system is the socio-cultural religious organization that acts as an effective tool for the implementation of communal ownership over common natural resources, and naturally, this traditional system is dialectically opposite to the corporate-controlled modern nation-state concept.

2nd tier ("Pir / Pargana Mahal" or inter village council): Inter village council is composed of 50 to 60 Santal villages with sufficient representation from each village with some elected social communal leaders (elected for five years) such as:

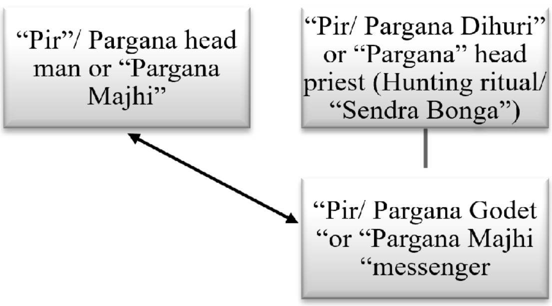


Figure 6 : Structure of "Pargana Majhi" system in a Santal dominated villages

3rd tier ("Disam-Pargana-Majhi" or regional council): "Disam-Pargana-Majhi "system or regional council is designated as 3rd tier of Santal social communal organization and is composed of 5 to 10 "Pargana" or inter-village councils with some elected (five-year term) social communal leaders such as;

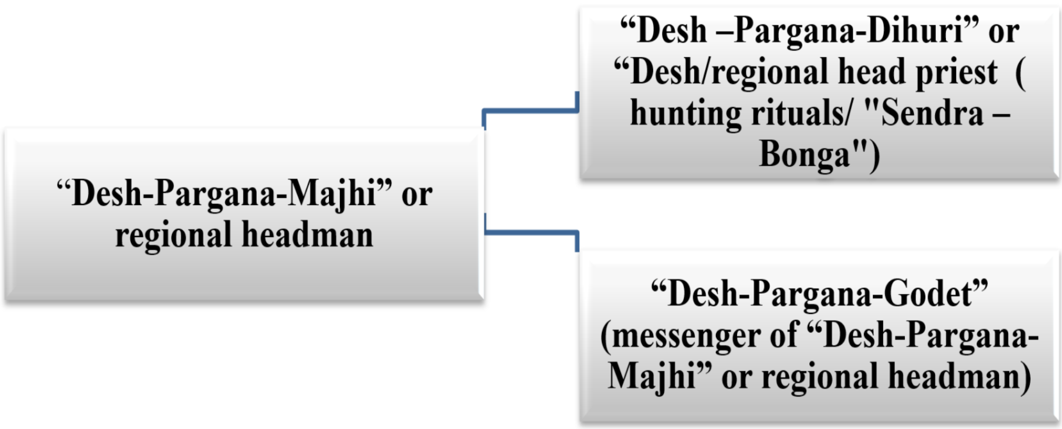


Figure 7 : Structure of the "Desh Pargana Majhi" system in a Santal-dominated village

According to Sri Kanuram Soren, leader of the "Save Hill" or "Pahar Bachao" movement of Kajura (also "Majhi" or village headman of Kuilatola), this three-tier decentralized egalitarian communal social system of the Santal community is effectively used for sudden public mobilization through their vertically stratified societal system with oral communications. These social systems of Santals are effectively used through from a tiny village space to more large regional space within a very short period of time. At any stage of development, the horizontal spatial spread of social movement through different diffusion processes is quickly aggravated by sudden temporal change from low to high intensity. And it is only possible when any indigenous social decentralised organisation like the "Majhi-Pargana-Disam" system is active both in the social and cultural life of the political space. With the help of the "Desh-Pargana-Majhi" system, the "Save Hill" movement of Kajura was spread all over Kajura within a short period of time.

d) Impact of social media and other sources for spatial spread from Kuilatola to other mouzas of Kajura Gram Panchayat region

Another system of spread of this political social movement ("Save Kuilatola Hill" movement) from Kuilatola sub-mouza to other parts of Kajura was quick by using different virtual and physical meetings through different social media and print media platforms and platforms of political activities of physical space, as said by villagers of Kuilatola, as shown below.

Table 3: Different mediums of spreading Save Hill movement from Kuilatola to other villages of the Kajura gram panchayat region (Opinion from Kuilatola sub-mouza)

Caste compositions of households of Kuilatola	From different WhatsApp groups	From different Facebook pages/ group pages	Meetings at different levels of Santal social and political organizations (such as meetings at "Majistan", "Pargana stan", and "Disamstan")	From newspaper reports/ political pamphlets/ political bulletins, etc.	Spreading of news through oral tradition
1 Santal household (48 families) (ST)	35%	21%	40%	02%	02%
2. Dom households (SC) (4 families)	40%	20%	05%	15%	20%
3. Paramik households (SC) (5 families)	-----------	13%	12%	13%	62%
Total (57 households)	25%	18%	19%	10%	28%

Source: *Field survey in November 2017, October 2018 and October 2019*

Observation on the spread of "Save Kuilatola Hill("Pahar")" movement from Kuilatola to other parts of the Kajura gram panchayat region

"Save Hill" movement of Kajura originated at Kuilatola sub mouza of Senara village in the first week of January 2016 and gradually spread to other sub mouzas, such as Gangarandi, Kodomdanga and the main village of Senara and the sub mouza of Kumorpara in the second week of this month. Apart from Kuilatola, the other two sub-mouzas, namely Gangarandi and Kodomdanga, are dominated by Santal communities, so easily accommodated through the traditional tribal system of "Desh-Pargana-Majhi" organisation. In the main village of Senara, some people of SC, OBC and forward communities were supportive towards the movement. According to Kanuram and other leaders of the movement, namely Joga Majhi, Haripada Tudu, Brojen Hashda and Daroga Murmu, within the latter half of the 2nd and the 1st half of the third week of January 2016, "pahar Bachao" movement suddenly expanded its core area to Shikrataur village, where a sufficient number of Santal people live. ***According to leaders of the movement that both in Senara and Shikrataur villages, there was a close understanding***

between to social traditional systems of village level administrative setup mainly between "Desh-Pargana-Majhi" system with village level "sholo-Ana" committee. This political gesture was helpful for "pahar Bachao" committee to get support from other communities.

Figure 8 : (A) Kuilatola hill (B) Postering of "Save Hill" movement (C) Abandoned project site (D) Abandoned project site at Kuilatola hill area

Table 4: sample households of all diffused zones of Save "Kuilatola Hill" movement at Kajura Gram Panchayat region

Name of zones of diffusion of save Kuilatola hill movement	Sample households (on the basis of social cluster)					
	SC	ST	OBC-B	HC	Total	%of total families of each zone
1. Places of origin (excluding the Kuilatola sub mouza)	64	23	40	02	129	15.58% (out of total no of families=828
2. Places of 1st diffusion	56	20	29	44	149	15.57%% (out of total no of families=957
3. Places of the 2nd diffusion	99	49	41	26	215	15.81% (out of the total no of families=1360)
4. Places of no effect of the Save Hill movement	15	-	43	19	77	20.10% (out of the total no of families=383)
Grand total =	234	92	153	91	570	16.16% (out of the total no of households at Kajura G.P. 3528)

Source: Field survey data of four consecutive household surveys in 2018 to 2019

A. Analyse the support pattern for the "Save Kuilatola hill" movement.

In this part, we first assessed the support pattern of this political social movement in the core area of places of origin of the movement at Kuilatola sub-mouza, where we found 100% support for the movement. In the other parts, we found the opinion of the sample households in the following way:

Spatial distribution of support pattern

The study reveals that the places of origin, 1st diffusion, 2nd diffusion, and areas of no effects of Save Hill movement have the highest support for Save Hill movement, with total support at these locations being 65.23%, 28%, 43.71%, 12%, 100%, and 42.36% in all zones of Kajura Gram Panchayat.

ST households show the highest support for the Save Hill movement, followed by SC and OBC-B households. Partial support is highest among higher caste households. Support is highest among ST households in all zones and places of origin. Total support is highest among ST, SC, OBC-B, and higher caste Hindu households. Many households in the Kajura Gram Panchayat region are partially or fully opposed to the "Save Hill" movement due to fear among landowners and non-tribal households, who perceive it as a religious tribal movement led by tribal leaders.

The total opposition pattern towards the Save Hill movement was calculated, with 17.37% at the origin, 27.25% at the 1st diffusion, 30.82% at the 2nd diffusion, 52.50% at places with no effects, and 29.17% at all zones in the Kajura gram panchayat region. There is a significant opposition towards the Save Hill movement among different caste groups, with OBC-B households showing the highest opposition.

The above-mentioned data on "don't know" indicates that a significant number of nontribal sample households are not attached to this movement. According to their view (already mentioned), this Save Hill movement was a religious movement of the tribal community of the Kajura Gram Panchayat region.

Main factors/ reasons responsible for the development of the "Save Hill" movement of the Kajura region

We try to identify the main reasons for the development of the Save Hill movement at different villages in the Kajura Gram Panchayat region. In our questionnaire, we identified some basic reasons and tried to get the opinion of sample households of different zones of the Kuilatola Hill movement. The question was: What is the main factor for the development of the Kuilatola Hill movement at different zones of the Kajura Gram Panchayat region? And options are as follows:

a) Spatial spiritual factors (religious beliefs associated with “Sarna Dharma”)

b) Spatial religious factors (religious belief of sacred space associated with Hindu religious identity)

c) Both (a+b)

d) To protect the local environment

e) To protect local “Geo-diversity”

f) No economic benefits from the stone mine project

g) Oppose the project due to political reasons

h) Other factor (such as sudden spontaneous participation)

i) Bad to worst performances of the local panchayat and the line department of the government

j) “Don't know” and refused to respond

Table 5: Main factors/ reasons responsible for the development of the “Save Hill” movement of Kajura region (in %)

Name of zones of diffusion of Save Kuilatola hill movement, caste composition of sample households	caste composition of sample households	a	b	c	d	e	f	g	h	i	j
A. **Kuilatola sub mouza (core area of origin of Save Hill movement) **	SC	50	25				25				
	ST	100									
	Total	75	12.50				12.50				
B. Places of origin (excluding the Kuilatola sub-mouza)	SC		50	20	10		10			10	
	ST	100									
	OBC-B	-	18		18		30				34
	HC	-	20		10	10	20			20	20
	Total	25	22	5	9.50	2.50	15			7.50	13.50

C. Places of 1st diffusion	SC		20		20	-	10			10	40
	ST	100									
	OBC-B		20		10	10	10			20	30
	HC		20		20	10	10			20	20
	Total	25	15	-	12.50	5	7.50	-		12.50	22.50
D. Places of 2nd diffusion	SC	10	30	10	10		15			15	10
	ST	100									
	OBC-B			14	10	1.00	28			29	18
	HC			23			7			56	14
	Total	27.50	7.50	11.75	5.00	0.25	12.50			25	10.50
E. Places of no effect of the Save Hill movement	SC	-	10	30						10	50
	ST	N. A									
	OBC-B	-	-	-	10	10	20			40	20
	HC	-	-	-	10	10	20			50	10
	Total	-	3.33	10	6.67	6.67	13.33	-	-	33.33	26.67
Grand total	Total SC	12	27	12	8.00	-	12	-	-	9.00	20
	Total ST	100									
	Total OBC-B	-	9.50	-	12	5.25	22	-	-	22.25	29
	Total HC	-	10	-	10	7.50	14.25	-	-	36.50	21.75
	Total	28	11.63	3.00	7.50	3.19	12.06	-	-	16.94	17.68

Source: *Household surveys in 2018 to 2019*

**** = In the case of Kuilatola sub-mouza, the total households of this sub–mouza was taken in the interview survey.

- It is evident from Table No. 5 that tribal sample households of all zones of the Save Hill movement, with total ST households of the core region of Kuilatola, have expressed their opinion that they were totally engaged in this movement to protect their sacred places from corporate greed. Even a small number of SC sample households made their opinion similar to their tribal neighbourhood (28% of total sample households said that the spatial spiritual factor was mainly responsible for mass mobilisation in favour of the movement).
- 11.63% of total sample households (27% of total SC, 9.50% of total OBC-B, and 10% of total higher caste Hindu sample households) said that the spatial religious factor was the main factor of motivation for mass mobilisation in favour of the movement.
- 3% of total sample households (12% of SC sample households) believed that both the spatial spiritual and spatial religious factors are responsible for the development of the Save Hill movement.
- If we consider the factors of sacred place (spatial spiritual spatial religious both) as a combined figure, then 42.63% (28%+11.63%+3%) of total sample households have made their opinion that factors of sacred places are the main factors for the development of the Kuilatola hill movement in the Kajura Gram Panchayat region. Caste-wise opinion on factors of sacred places is as follows:

- 100% of total ST sample households = factors of sacred places
- 51% of total SC sample households = factors of sacred places
- 9.50% of total OBC-B sample households = factors of sacred places
- 10% of total HC sample households = factors of sacred places.
- 7.50% and 3.19% of total sample households said that both the protection of the local environment and Geo-diversity are the main concerns behind the mass mobilisation in favour of the Save Hill movement.
- 12.06% of total sample households (12% of SC, 22% of OBC-B, and 14.25% of general category sample households) said that these types of large corporate-controlled stone mines are not economically beneficial for local people. Actually, a very small number of local people get jobs from this type of project. So, this is the reason for their opposition to the project.
- 16.94% of total sample households (9% of SC, 22.25% of OBC-B, and 36.50% of caste Hindu/higher caste) said that the worst performance of both local panchayat and line departments of the government in the field of local economic development is the main reason for mass mobilization and support for the movement.
- 17.68% of total sample households (20% of SC, 29% of OBC-B, and 21.75% of general category/higher caste Hindu) are refused to respond to this particular question.

Relationship between reasons for the development of movement and with support pattern of the movement

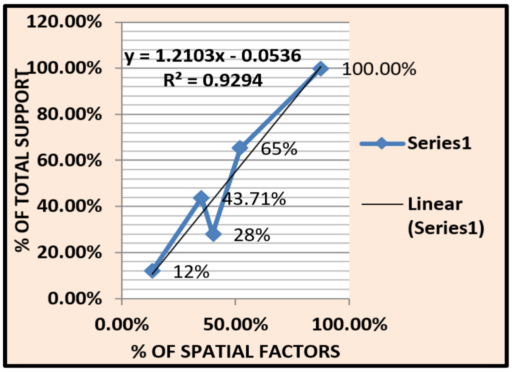


Fig. 7: Positive Relationship Between % of Spatial Factors With % of Total Support at Different Zones of Save Hill Movement at Kajura Region, Purulia

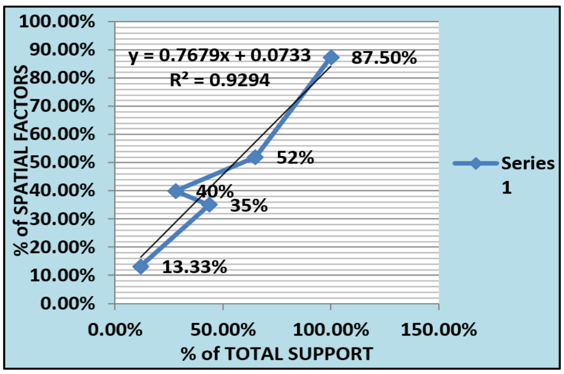


Fig. 8: Positive Relationship Between % of Total Support and % of Spatial Factors at Different Zones of Save Hill Movement at Kajura Region, Purulia

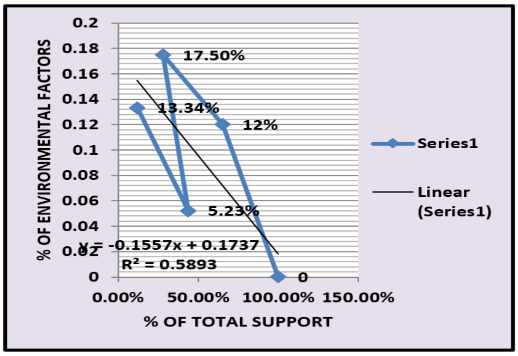


Fig. 9: Negative Relationship Between % of Total Support With % of Environmental Factors at Different Zones of Save Hill Movement at Kajura Region, Purulia

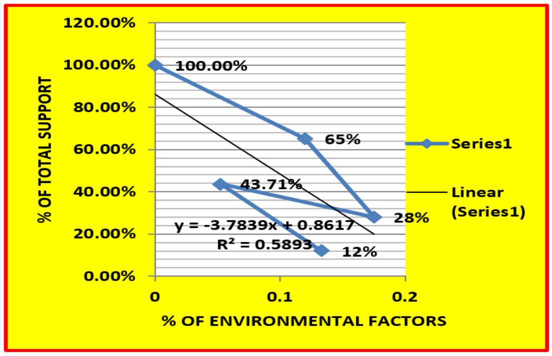
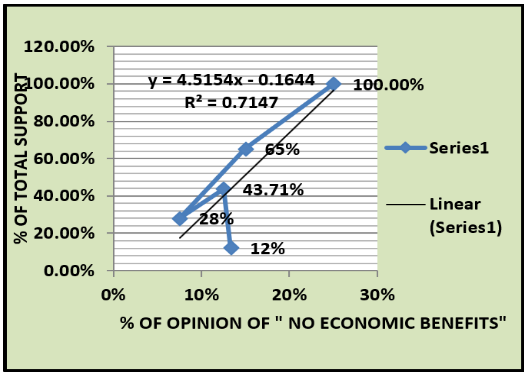


Fig. 10: Negative Relationship Between % of Environmental Factors And % of Total Support at Different Zones of Save Hill Movement at Kajura Region, Purulia



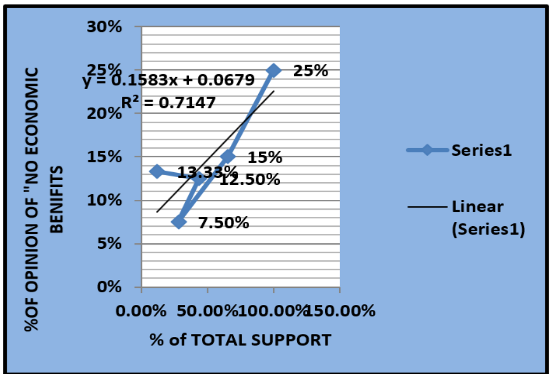


Fig. 11: Positive Relationship Between % of Opinion of " No Economic Benefits" With % of Total Support at Different Zones of Save Hill Movement at Kajura Region, Purulia

Fig. 12: Positive Relationship Between % of Spatial Factors With % of Total Support at Different Zones of Save Hill Movement at Kajura Region, Purulia

It is evident from these two scatter diagrams (Fig. 8 and 9) that there are positive relationship between % of total support and % of spatial factors (spatial reasons for development of Save Hill movement). Both these variables are influenced each other and it is evident from this fact that there is symmetry between total support and spatial factors. Total support for Save Hill movement is influenced by spatial factors and vice versa.

Both scatter diagrams (Fig. 10 and 11) show a positive relationship between % of total support and % of public opinion of "no economic benefits," indicating influences of economic factors over public mobilization in favor of the Save the Hill movement.

It is evident from both Fig. 12 and 13 that there is negative relationship between % of total support with % environmental factors (% of public opinion on environmental factors).

It is evident from this pie diagram that majority of public opinion is shown that spatial factors are the main factors for mass mobilization in favor of Save Hill movement at Kajura region. 18 % (17.68%) of total sample households are refused to comment in that particular question. 16.94% or 17% of total sample households said that bad to worst performance of both local Gram Panchayat and line department of government is also responsible for both increasing partial and total support for the Save Hill movement at Kajura region.

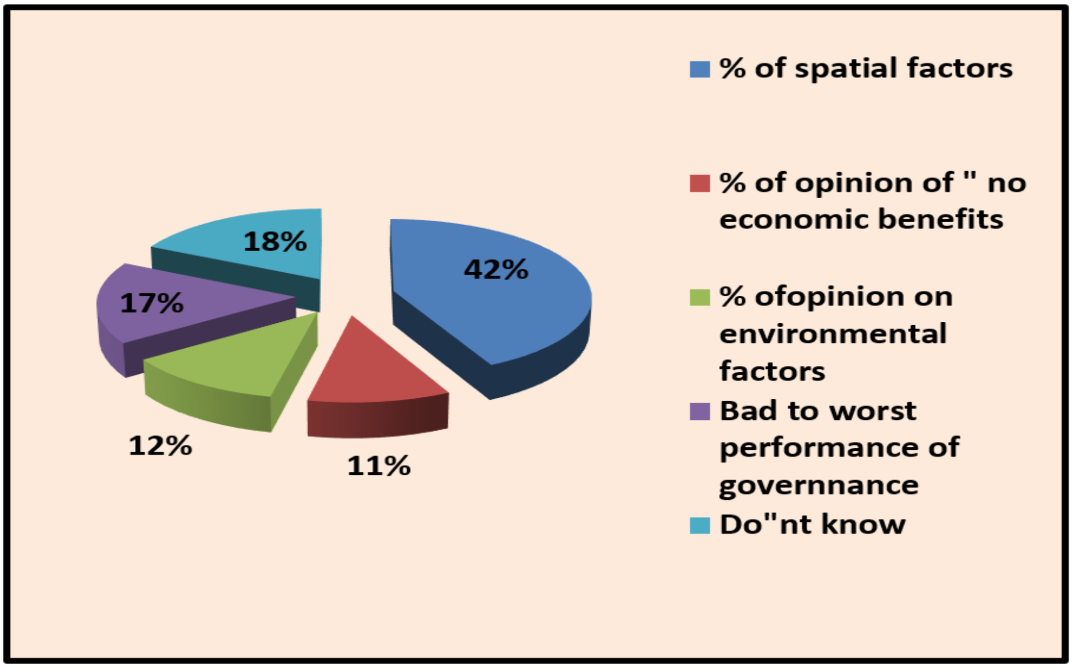


Figure 14: % Main Factors Responsible for Development of Save Hill Movement at Kajura G.P. Region, Purulia (Public Opinion of Sample Households of Four Zones and Total Households of Kuilatola Sub Mouza)

Analysis of both support and opposition base of the Save Hill movement of Kajura and ultimate consequences:

From our field surveys both in 2018 and 2019, we tried to find out the popular support and opposition towards the "Save Hill" movement of Kajura region at all zones with the following characteristics:

a) 100% of Santal sample families of all zones of the “Save Hill” movement of the Kajura panchayat region are fully supportive both in 2018 and 2019, respectively, indicating hidden ethnic aspirations of this social movement.

b) A significant number of SC, OBC-B, and general category sample households are partially supportive of the movement, indicating a popular mass base of the movement at a certain point in time. Both spatial and temporal factors play a very influential role in this context, as it is evident that at the time of repeated interviews with the same sample families in 2019, there is a sudden increase in support in favor of the “Save Hill” movement from different sub-caste groups of SC, OBC-B, and Caste-Hindu (general) category sample households that are partially still supportive towards the movement. Now the question arises: why this “Save Hill” movement of Kajura, with its hidden ideology of ethnic aspiration, suddenly turned into a mass movement with near equal participation of other castes and communities, particularly at Digtala, Digardi, Bundla, Chinpina, Talsakra, Uppar-Sakra, and other villages? The answer will be multi-dimension, as shown below:

Conclusion

Save Hill movement of Kajura region led exclusively by Santal community creating a sense of insecurity among rural elites, and they are tactically and indirectly opposing the movement but also aware of the politics of votes and consolidation of votes of our electoral politics, so this nature of electoral politics pursuing the government to temporally abandon the “Kuilatola mechanized stone mine project,” popularly known as the “Senara project." On the other hand, the Save Hill movement of Kajura has created a sense of hidden class struggle with support from other poor marginalized communities, from small and middle farmers to all segments of wage workers representing other non-tribal communities trying to create the counter power of the toilers class through the struggle for conservation of space of “commons” of Kajura, and it implies that the Save Hill movement of Kajura is more inclusive with hidden popular support. Space struggle is the new class struggle at Kajura in the twenty-first century.

Acknowledgement: We are grateful to the leaders, activists, supporters of the Save Hill movement of Kajura Gram Panchayat region, villagers of Kuilatola sub-mouza, and other villages for their selfless support, help, and tender-hearted cooperation in preparing this paper.

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SUSTAINABILITY IN RESILIENCE, SOCIAL PREPAREDNESS AND FLOOD RISK MANAGEMENT FOR COMMUNITY DEVELOPMENT IN THE THRISSUR DISTRICT OF KERALA

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ABSTRACT

The escalating frequency and severity of natural disasters, compounded by climate change, underscore the critical necessity for sustainable disaster management practices. This study focuses on the Thrissur District, Kerala, as a case study due to its cultural significance and vulnerability to floods, landslides, urbanization, climate hazards, and coastal erosion. The present study embodies a collective endeavour towards ensuring the safety, preparedness, and sustainability of the community in the face of unforeseen emergencies. By integrating preparedness, good governance, and policy implementation, this research aims to protect communities, preserve livelihoods, and promote sustainable development in Thrissur.

Data collection employed a combination of primary and secondary sources, including surveys, interviews, literature reviews, and data from official sources. Findings revealed high flood awareness among the younger demographic, emphasizing the need for targeted preparedness initiatives. Key challenges identified include infrastructure vulnerabilities, food, water shortages, and health issues. Sustainable suggestions and mitigation measures emphasize collaboration, innovation, and ecological integration into flood risk management strategies, aligning with global sustainable development and climate resilience goals.

The findings of the study underscore the vital importance of integrating preparedness, good governance, and policy implementation to foster sustainable disaster management. By focusing on Thrissur District as a microcosm of broader climate and disaster resilience challenges, the research highlights the necessity of a comprehensive, collaborative approach to disaster risk reduction. The findings and recommendations offer a pathway for building resilient communities capable of withstanding and recovering from natural disasters, thereby contributing significantly to sustainable development and climate resilience efforts globally.

Keywords : *Community Development, Flood Risk Management, Social Preparedness, Sustainability, Thrissur*

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Introduction

Disasters are events that cause significant damage, destruction, and distress to communities and their surroundings. Understanding the causes, impacts, and management strategies of disasters is crucial for effective preparedness and response. Disasters occur when hazards, or potential threats, manifest and overwhelm the affected community's capacity to cope, necessitating external assistance. Organizations such as the United Nations Office for Disaster Risk Reduction (UNDRR), the International Federation of Red Cross and Red Crescent Societies (IFRC), and the World Health Organization (WHO) emphasize the severe impacts of disasters and the need for effective management strategies.

Floods, one of the most common natural disasters, involve the temporary covering of land by water beyond its normal confines. They can result from various causes, including heavy rainfall, snowmelt, sea surges, and dam breaks. The sudden inundation caused by floods severely affects infrastructure, public health, and communities' resilience especially the farmers (George et al., 2022). India, with its diverse topography and climatic conditions, is highly vulnerable to floods. The country's geographical, environmental, and socio-economic factors contribute to this susceptibility. Coastal areas are prone to cyclones and storm surges, while the monsoon climate leads to annual floods in riverine plains. Rapid urbanization, inadequate infrastructure, and environmental degradation further increase vulnerability, exacerbated by climate change, which leads to more frequent and intense extreme weather events.

Kerala, a state in southern India, is particularly susceptible to floods due to its unique geography, including a network of rivers, backwaters, and a monsoon climate. The southwest monsoon brings intense rainfall, causing Rapid River swelling and waterlogging. The state's topography, featuring the Western Ghats and coastal plains, influences rainfall patterns and water flow. Kerala is considered a state with abundant water availability. However, a recent study established that the net per capita water availability is far below the drier states of India such as Rajasthan and Maharashtra (Nair, 2008). In fact, rampant sand and clay mining in the state of Kerala have largely interfered with the flow regime of many of the tributaries (N. Raj and Azeez, 2010). Recent floods in 2018 and 2019 highlighted the severe impacts of heavy rainfall, poor land-use practices, and inadequate water management infrastructure, leading to widespread destruction and displacement (Lakshmi et al., 2021). Livelihood stabilization focusses on household income security and ensuring economic productivity (Daly et al., 2020).

Despite the recurring nature of floods, community engagement in disaster preparedness in Kerala remains insufficient. Effective flood risk management requires local community involvement, leveraging their knowledge and fostering a sense of collective responsibility. This study focuses on flood risk mapping and community involvement in disaster preparedness in Thalappally Taluk of Thrissur District. By mapping flood risks, vulnerable areas can be identified, aiding better urban planning and infrastructure development. Engaging the community enhances resilience through local knowledge sharing, early warning systems, and adaptive response strategies, ultimately reducing flood impacts and improving overall resilience.

The 2018 floods underscored the urgent need for effective flood risk management and community resilience. Urban resilience for any city is a gap to be fully understood and assimilated in urban planning (Ali and George 2021). Urban resilience, especially for disaster-prone areas like Kerala, is essential but challenging to fully integrate into urban planning. Sustainable infrastructure planning, including flood-resistant buildings and efficient drainage systems, is vital. Good governance and effective policy implementation ensure these strategies are enforced, promoting collaboration among stakeholders, and fostering transparent, accountable decision-making. Preparedness involves comprehensive planning, regular training, and early warning systems to equip communities to respond effectively to floods. Educational institutions play a crucial role by incorporating disaster management into their curricula, raising awareness, and serving as hubs for information dissemination. This comprehensive approach aligns governance and policy with broader educational goals, ensuring sustainable development and enhanced urban resilience in Kerala. This study underscores the importance of integrating preparedness, good governance, and policy implementation to foster sustainable disaster management. By focusing on Thrissur District as a microcosm of broader climate and disaster resilience challenges, the research advocates for a comprehensive, collaborative approach to disaster risk reduction. The findings and recommendations provide a pathway for building resilient communities capable of withstanding and recovering from natural disasters, significantly contributing to global sustainable development and climate resilience efforts.

Statement of the Problem

Thrissur District, Kerala, is highly vulnerable to recurring floods, posing significant risks to the community's safety and livelihoods. Despite various flood management efforts, there is limited understanding of the current level of awareness and knowledge about floods among the residents, as well as their preparedness in terms of disaster response, including evacuation procedures and early warning systems. The effectiveness of existing mitigation measures and community-based management strategies for reducing flood risks and enhancing resilience remains unclear.

Moreover, the community's suggestions and feedback regarding potential improvements to flood management practices are not well-documented, hindering the development of tailored and effective interventions. This study seeks to address these gaps by investigating the current state of flood awareness, preparedness, and existing mitigation strategies in Thrissur District.

By answering the following research questions, the study aims to develop actionable recommendations for strengthening flood risk management and community resilience:

1. What is the current level of awareness and knowledge about floods among respondents in Thrissur District, Kerala?
2. How prepared is the community in Thrissur District regarding disaster response, including evacuation procedures and early warning systems?
3. What mitigation measures and community-based management strategies are currently in place in Thrissur District to reduce flood risks and enhance resilience?
4. What suggestions and feedback do respondents have for improving flood management practices and community resilience in Thrissur District?
5. What recommendations can be developed based on the study's findings to strengthen flood risk management and community resilience in Thrissur District, Kerala?

Studying flood risk management and community-based management in Thrissur District is crucial to enhancing community resilience, ensuring effective planning, and aligning with broader disaster risk reduction goals, particularly given the district's susceptibility to floods and their significant impacts on local communities.

Significance of the Study

Mapping flood risks and engaging the community in disaster preparedness are crucial for effective flood management in Thrissur District, Kerala. Flood is viewed as a tension, whose damages can be reduced by identifying vulnerable areas (Avand et al., 2023). This study aims to identify vulnerable areas, enhance risk assessment, and develop sustainable infrastructure plans. By evaluating disaster response preparedness, the study will help prioritize mitigation measures such as flood barriers and improved drainage systems, aligning with good governance and policy implementation.

Community engagement is vital for resilience; this study will gather local insights and foster ownership through risk mapping, disaster drills, and awareness campaigns. Enhancing early warning systems ensures timely, accurate alerts, enabling proactive measures to protect lives and property. The study's adaptive planning approach will tailor response strategies to specific flood scenarios, ensuring efficient and responsive actions. Building community resilience through knowledge sharing, skills development, and capacity building is a key focus. By aligning governance through a bottom-up approach and policy with broader educational goals (Mc McClymont et al., 2019), the study promotes comprehensive and sustainable flood risk management practices. In Thrissur District, these efforts are fundamental for reducing vulnerabilities and mitigating the impacts of floods on lives and livelihoods.

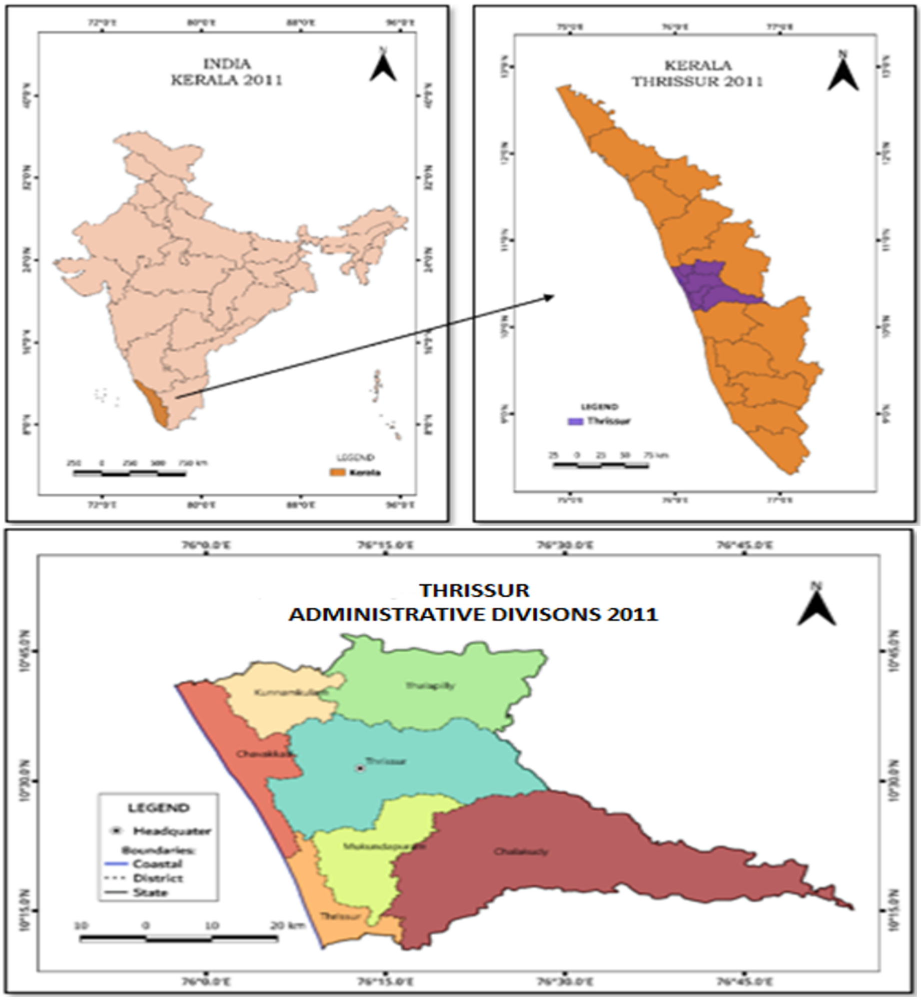
Objectives of the Study

In line with the significance of the study discussed above the present study has the following aims and objectives, aligned with preparedness, good governance, policy implementation, and sustainable institutions:

1. To assess the level of awareness and knowledge about floods among respondents in Thalappally Taluk of Thrissur District, Kerala, focusing on their understanding of flood risks, potential hazards, and disaster response strategies. This objective highlights the importance of understanding the concept of preparedness for a Disaster Management Plan.
2. To evaluate the disaster response preparedness of the community in Thalappally Taluk of Thrissur District, Kerala, including their familiarity with evacuation procedures, early warning systems, and coordination during flood events. This objective emphasizes the need for preparedness and effective disaster management planning, particularly in educational institutions to ensure sustainable development.
3. To identify and analyze the existing mitigation measures and community-based management strategies employed in Thrissur District for flood risk reduction and resilience enhancement. This objective aligns with sustainable infrastructure planning and the importance of community-based management strategies in achieving sustainability.
4. To gather suggestions and feedback from respondents regarding potential improvements and interventions to strengthen flood management practices and community resilience in Thalappally Taluk of Thrissur District, Kerala. This objective focuses on good governance and policy implementation, seeking community input to enhance governance and policy frameworks.
5. To synthesize the findings from the questionnaire responses to develop recommendations and actionable strategies for effective flood risk management and community resilience building in Thrissur District, Kerala. This objective aims to align governance and policy with broader educational goals, ensuring comprehensive and sustainable disaster management practices that foster resilient communities.

Geographical Profile of the Study Area

Thrissur, established on July 1, 1949, is Kerala's cultural capital, famous for its “Pooram” festival, artistic traditions, and historical landmarks. Strategically situated between the Arabian Sea and the Western Ghats, it boasts diverse economic sectors like agriculture, tourism, textiles, and trade. Its strong infrastructure includes well-connected roads, railways, and air transport. Thrissur District in Kerala is administratively divided into 7 taluks (sub-districts): Thalappilly, Kunnamkulam, Chavakkad, Thrissur, Mukundapuram, Chalakudy, Kondungullar (see fig 1). Thrissur is also divided into two Revenue Subdivisions: Thrissur (Thrissur, Chavakkad, Thalappilly, Kunnamkulam) and Irinjalakuda (Mukundapuram, Chalakudy, Kodungallur), each led by a Revenue Divisional Officer. Governance is managed through Taluk and Village administration by the state, Panchayath Administration by local bodies, and representation in Parliament and the Kerala Assembly. This structured setup ensures effective governance, decision-making, and resource allocation, catering to Thrissur's diverse population and needs.



Source: Based on Census of India, 2011 (using Map Info GIS Software, 2024)

Figure 1: The Study Area

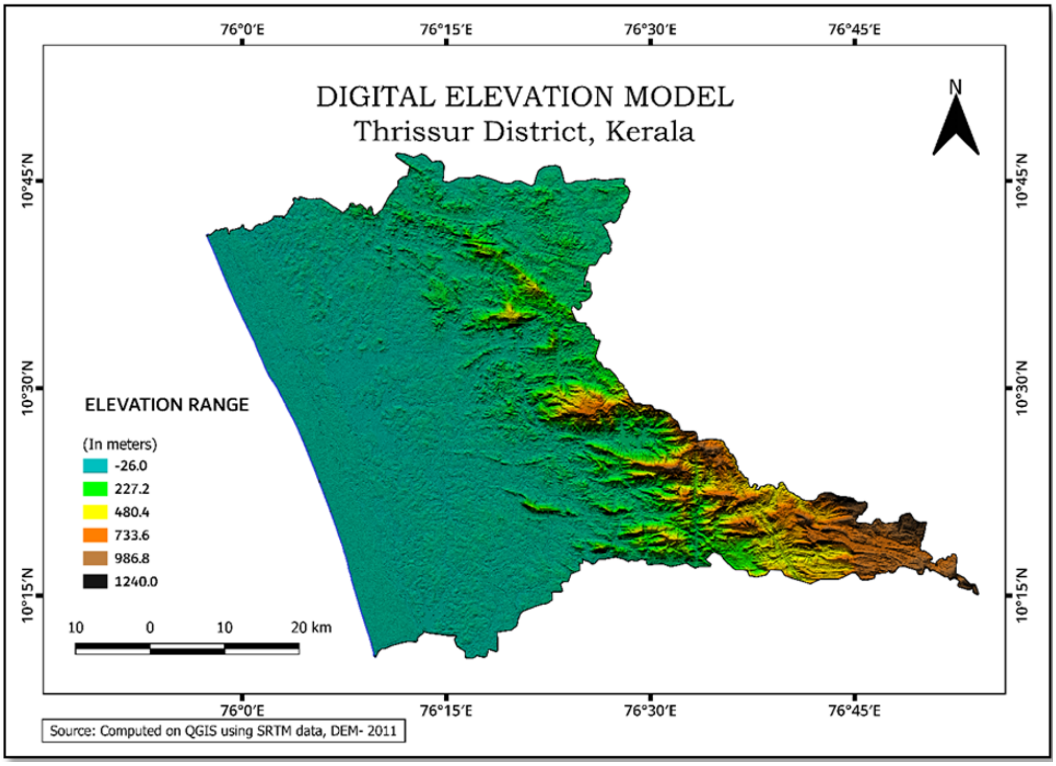


Figure 2: Elevation Level of Thrissur

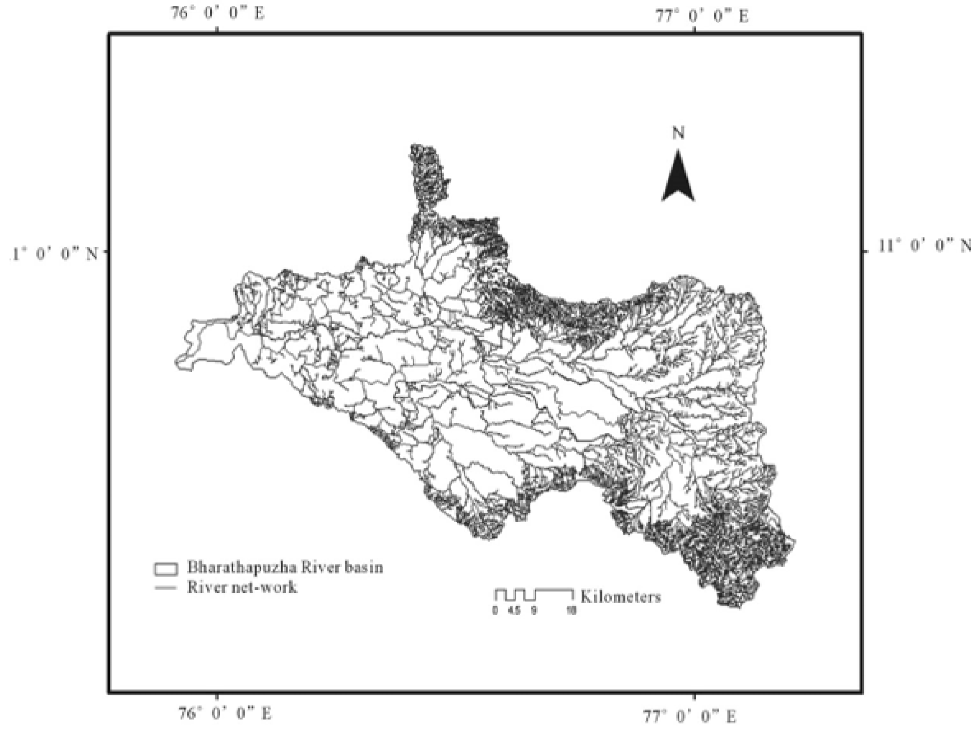
Hazard and Vulnerability Profile of Thrissur District, Kerala

Thrissur District in Kerala faces multiple natural hazards due to its geographical location and climate. Frequent floods and landslides, especially in the Western Ghats, alongside droughts and water scarcity during summers, pose significant risks. The district's humid, tropical climate, influenced by the South-West and North-East monsoons, leads to heavy rains and urban flooding. Thrissur falls under seismic Zone III, indicating earthquake vulnerability. Rapid urbanization exacerbates these challenges, while coastal erosion affects 63% of Kerala's coastline. The Government of Kerala emphasizes proactive disaster management strategies, including improved infrastructure, urban planning, early warning systems, and sustainable practices to enhance community resilience.

River System

Thrissur District in Kerala is part of the larger river system that characterizes the region's hydrology. The river system in the district is integral to its geographical and ecological landscape.

The Bharathapuzha River floodplain is one of the main causes of floods in Thrissur District, Kerala. The drainage pattern of the river Bharathapuzha is dendritic in nature (Sree devi et al., 2004). 11 dams and irrigation projects are nested in the river basin catering 4,93,064 hact. of land to cultivation (CWRDM, 2004; Ravi et al., 2004). Being a significant river in the region, Bharathapuzha's floodplain is extensive, and during periods of heavy rainfall or monsoon seasons, it can overflow, leading to flooding in nearby areas. The annual discharge recorded of the river at its confluence is of the intensity 3.94 km^3 (N. Raj and Azeez, 2009). Geologists reclaim this basin as a successor to a westerly flowing palaeo-river way back to the post Mio-Pliocene times (Jacob and Narayanaswamy, 1954; Subramanian and Muraleedharan, 1985; Vaidyanathan, 1971). Flooding from the Bharathapuzha River floodplain is a recurrent challenge that the local communities and authorities have to manage and mitigate to reduce the impact on residents and infrastructure in the district. Figure 3 depicts the locational settings and drainage system of the Bharathapuzha river in Kerala. There are 5 Hydrological Observation Stations on this river maintained by Central water Commission i.e., at Kumbidi, Pulamanthole, Mankara, Pudur and Amabarampalayam.



Source: *Derived from Nikhil Raj and Azeez (2012)*

Figure 3: Location and Drainage System of Bharathapuzha

The Bharathapuzha River Basin includes sub-basins as Chittur basin, Kalpathy basin, Gayathri basin and Thootha basin. Table 1a & b below depicts morphometric analysis that is needed to understand the hydrological and morphological characteristics of the river basin which is a combination of relief aspects, linear aspects, and shape aspects of the catchment (Sruthy et al., 2024). It depicts the basin and sub-basin wise number of streams, stream order and bifurcation ratio. A relatively higher order of stream, (being 7 with a mean bifurcation ratio of 4.24) in the Bharathapuzha river basin and similarly high values for its sub-basins-indicates intense flooding in the adjoining areas in the district of Thrissur in Kerala.

Table 1(a): Number of Streams and Stream Order (Bharathapuzha River Basin)

Basin Name	Basin Area (Km2)	Stream Order	Stream Order (Numbers)						
			1	2	3	4	5	6	7
Bharathapuzha River	6102	7	5628	1321	324	70	19	5	1
Chittur	1314	7	2162	494	115	22	6	2	1
Kalpathy	1390	6	1198	291	73	18	5	1	
Gayathri	1084	6	633	165	84	8	3	1	
Thootha	1015	6	1325	296	72	17	5	1	

Source: *Derived from Nikhil Raj, P. A. Azeez (2012)*

Table 1(b): Bifurcation Ratio (Bharathapuzha River Basin)

Basin Name	Bifurcation Ratio (RL)						Mean Bifurcation
	1	2	3	4	5	6	
Bharathapuzha River	4.26	4.08	4.63	3.68	3.80	5.00	4.24
Chittur	4.28	4.3	5.23	3.67	3.00	2.00	3.76
Kalpathy	4.12	3.99	4.06	3.6	5.00		4.15
Gayathri	3.84	3.75	5.50	2.67	3.00		3.75
Thootha	4.48	4.11	4.24	3.40	5.00		4.24

Source: *Derived from Nikhil Raj & Azeez (2012)*

Database and Methodology

The study employs a comprehensive mix of primary and secondary data sources to ensure robust and thorough research. Primary data is collected through online surveys administered via Google Forms and interviews with a family native to Thrissur, Kerala, currently residing in Noida, Uttar Pradesh. The surveys gather quantitative data on flood awareness and preparedness, while the interviews provide qualitative insights into community responses and resilience during floods. Secondary data is obtained through an extensive literature review of academic articles, journals, books, and conference reports, offering a theoretical framework for flood risk management and community resilience. Additional data is sourced from the NDMA and Government of Kerala websites. A mixed-methods approach integrates these primary and secondary sources, enriching the analysis by cross-referencing interview responses with documented disaster management protocols. Ethical considerations, such as informed consent and confidentiality, are strictly adhered to throughout the data collection process.

The study employs a comprehensive research methodology combining quantitative and qualitative data collection methods. Surveys with both close-ended and open-ended questions were administered online to assess disaster management preparedness and past flood experiences among respondents in Thrissur District. Structured interviews were conducted with a native family, including male, female, and young adult members, providing qualitative insights into community roles, responsibilities, and challenges during disasters. Additionally, storytelling from the family enriched the data with a narrative-based perspective on the 2018 Kerala floods. Data representation utilized pie charts, bar graphs, radial diagrams and band graphs. Additionally, QGIS is employed to visualize survey responses and create maps of Thrissur's administrative divisions, topography, and river systems. The application of GIS provides visual impact and adds a digital dimension to the study (Vimod et al., 2022). The sample size consisted of 500 participants. Quantitative data have been analyzed using statistical techniques to identify patterns and correlations, while qualitative have been examined to reveal themes and insights into emergency preparedness. This mixed-methods approach ensured a robust and holistic understanding of disaster management preparedness in Thrissur District.

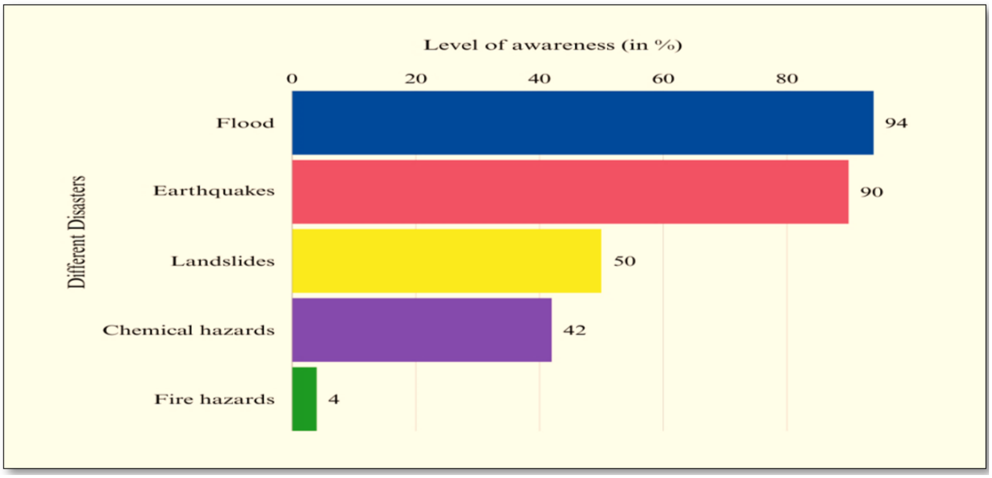
Result and Discussion

The results and discussion section of this study unfolds in a logical sequence, guiding the reader through four key areas crucial for effective flood risk management and community resilience in Thrissur District, Kerala. The first section, awareness and knowledge about floods, establishes the community's understanding of flood risks and their past experiences with flood events, providing a foundational context. Building on this, the second section, disaster response preparedness, evaluates the community's readiness to respond to flood emergencies, highlighting existing knowledge gaps and preparedness levels identified through their awareness. This naturally leads to the third section, mitigation measures and community-based management, which examines current strategies, communication channels, and training efforts aimed at reducing flood impacts, considering the community's preparedness levels. Finally, the fourth section, suggestions, and feedback for improvement, synthesizes insights into community perceptions of government support, emergency communication facilities, and identifies areas needing enhancement to bolster overall flood resilience. This structured approach ensures a comprehensive understanding of the current state of flood risk management and outlines actionable recommendations for future improvements.

Awareness and Knowledge About Floods

The age structure of respondents indicates a significant portion (44%) within the 15-24 age group, followed by 26% in the 25-39 age group, 22% in the 40-59 age group, and 8% aged 60 and above. This predominantly young population suggests higher levels of technological proficiency and digital literacy, which may lead to increased knowledge and awareness of disaster risks and preparedness strategies. However, leveraging the diverse experiences and knowledge of different age groups is essential for comprehensive and effective community engagement in disaster management.

Awareness of common disasters is high, with 94% of respondents recognizing flood risks, 90% aware of earthquakes, 50% aware of landslides, and 42% aware of chemical hazards, while fire hazards (4%) are less prevalent hence less known to the respondents (see fig. 4). The high awareness of flood risks highlights the need for targeted disaster preparedness efforts and community engagement strategies focusing on flood management and mitigation measures. Additionally, 68% of respondents had experienced floods in their locality, underscoring the importance of tailoring disaster preparedness initiatives to local experiences. Real-life testimonies from the 2018 floods emphasize the necessity of effective disaster management strategies in flood-prone areas, with many respondents recalling the need to shift to higher floors until government rescue operations commenced.

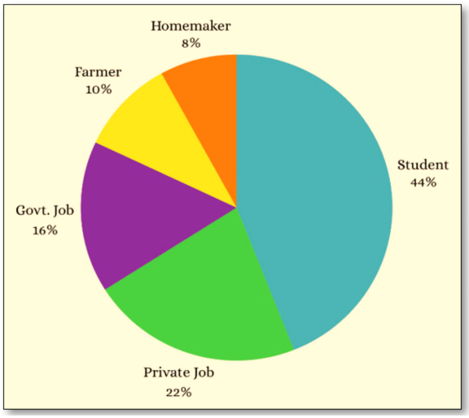


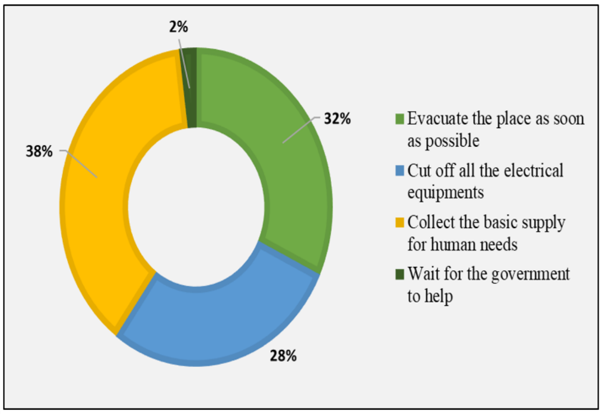
Source: *Primary Survey, 2024*

Figure 4 : Awareness Level of Disasters

Disaster Response Preparedness

Familiarity with response steps during floods is high, with 80% of respondents being aware of necessary precautions, indicating a reasonable level of preparedness. Figure 5a depicts the composition of occupational structure with regard to preparedness to floods indicating a dominance of student folk (44%) followed by people engaged in private and government jobs being 22% and 16% respectively.





Source: *Primary Survey, 2024*

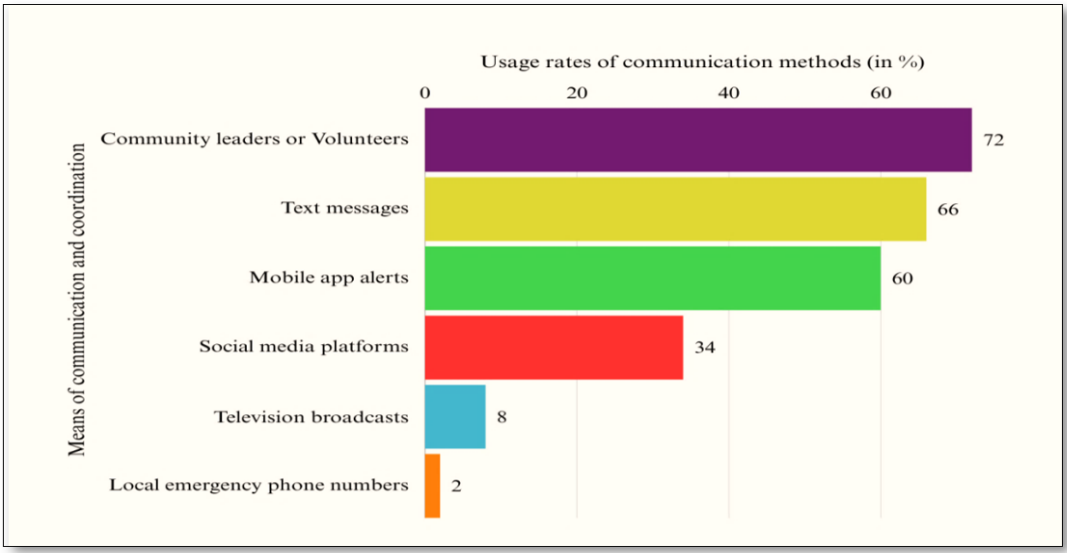
Figure 5(a): Occupational Structure

Figure 5(b): Initial Steps towards Flood Response

With regard to their immediate response to disasters, 14% expressed uncertainty and 6% were unaware of appropriate actions, highlighting the need for targeted education and awareness programs. In terms of initial response actions, 32% of respondents would evacuate immediately, 28% would cut off electrical equipment, and 38% would collect basic supplies, demonstrating a proactive approach to disaster response as depicted by figure 5b. Despite the overall preparedness, several gaps are evident. The uncertainty and lack of awareness among a notable percentage of respondents point to a need for targeted education and awareness programs. The varied initial response actions suggest a lack of standardized guidelines, and the small percentage of respondents who would wait for government help highlights a gap in self-reliance education. Furthermore, the heavy reliance on digital and broadcast mediums for emergency information suggests potential issues for those without access to these technologies, emphasizing the need for diverse communication strategies to ensure inclusivity. Addressing these gaps through targeted programs, standardized guidelines, and diversified communication strategies can significantly enhance community disaster preparedness and response.

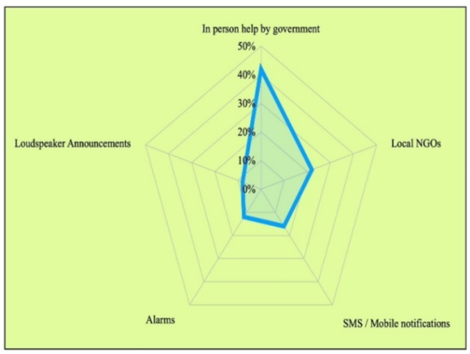
Mitigation Measures and Community-Based Management

The data analysis on communication and coordination during floods revealed significant reliance on community leaders or volunteers (72%) for organizing response efforts, followed by text messages or automated alerts (66%) for rapid information dissemination. Mobile apps or alert systems were utilized by 60% of respondents, with social media platforms (34%) and traditional media like radio or television broadcasts (8%) playing lesser roles. Only 2% mentioned using local emergency phone numbers (see fig. 6a).



Source: *Primary Survey, 2024*

Figure 6(a): Communication and Coordination during Floods



Source: *Primary Survey, 2024*

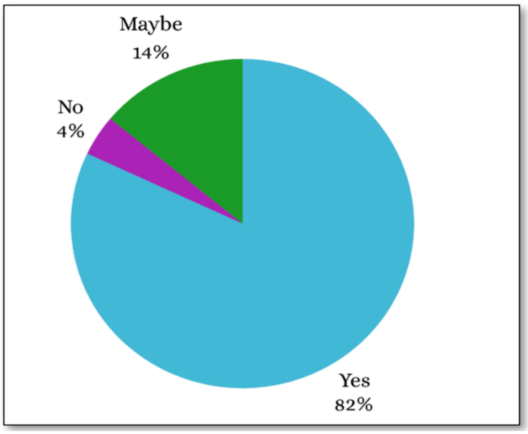
Figure 6(b) : Flood Preparedness Training

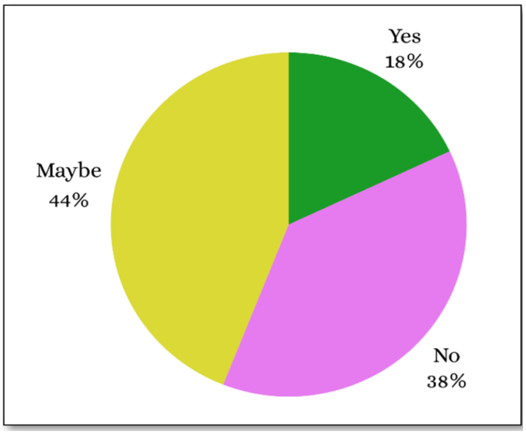
Figure 6(c) : Preferred Mode of Communication

Regarding flood preparedness 80% of respondents have received education and training, reflecting a proactive approach. However, 16% lacked training, indicating a gap that requires targeted programs. Uncertainty existed for 4% regarding their training status, necessitating clarity (see fig. 6b). For preferred mode of communication for emergency, 42% of the respondents needed in-person help by government, 22% by local NGOs, 16% wanted to be informed in advance via SMS/mobile notifications, 12% through alarms and 8% via loudspeaker announcements as depicted by figure 6c. Designated evacuation routes and shelters were lacking, as indicated by 48% of respondents, while 42% were unsure about their existence, suggesting a need for better communication and awareness campaigns. Only 10% confirmed their presence, indicating room for improvement in infrastructure planning and the need for targeted efforts to address uncertainty and enhance overall community resilience through effective communication channels and grassroots engagement.

Suggestions and Feedback for Improvements

The survey revealed that 82% of respondents believe the government offers crucial support during and after floods, indicating confidence in intervention measures. However, 14% were unsure, and 2% disagreed, suggesting room for improvement in service delivery. Concerning emergency communication facilities, 44% were uncertain about their availability, 38% believed they were lacking, and only 18% confirmed their presence. This emphasizes the need for robust communication infrastructure to bolster community resilience and response capabilities. Moreover, while 32% feel adequately prepared for floods, 40% are uncertain, and 28% believe their community lacks preparation. These mixed views highlight opportunities to enhance flood risk management, infrastructure resilience, and community engagement efforts (see fig. 7a & b).





Source: *Primary Survey, 2024*

Fig. 7(a): Confidence in Preventive Measures Provided

Fig. 7(b): Confidence in Availability of Communication

Sustainable Suggestions and Mitigation Measures

Flood risk management is a critical aspect of ensuring community resilience and sustainable development, particularly in flood-prone areas like Thrissur District, Kerala. The findings of our study on flood risk management and community resilience have revealed key insights into the challenges faced by the community during flood events. To address these challenges and promote long-term sustainability, sustainable suggestions and mitigation measures are essential. In this context, we present sustainable suggestions and mitigation measures that can contribute to enhanced flood resilience, reduced impacts, and long-term sustainability in a flood prone district of Kerala. These measures emphasize collaboration, innovation, and the integration of ecological principles into flood risk management strategies, aligning with global goals for sustainable development and climate resilience.

1. Construction of Embankments: Implementing protective barriers like levees and dams can contain floodwaters and minimize their impact on surrounding areas. To ensure sustainability, these embankments should be designed with ecological considerations, such as maintaining natural habitats and biodiversity.

2. Investing in Flood-Resistant Building Designs: Prioritize building and infrastructure designs that can withstand flood conditions. This includes using flood-resistant materials, elevating structures in flood-prone areas, and incorporating flood-proofing measures to reduce damage and disruption during flood events.

3. Promoting Sustainable Land Use Practices: Adopt sustainable land use practices that reduce runoff and erosion. This includes preserving natural vegetation, implementing green infrastructure solutions like permeable surfaces and rain gardens, and avoiding construction in high-risk flood zones.

4. Community Workshops and Training: Organize workshops and training sessions to educate the community about flood risk management, emergency preparedness, and sustainable practices. Encourage active participation and knowledge-sharing among residents.

5. Community-Based Monitoring and Early Warning System: Involve community members in monitoring flood risks and establishing early warning systems. Utilize local knowledge and resources to enhance the effectiveness of early warning mechanisms.

6. Community Resilience Committees: Establish community resilience committees comprising diverse stakeholders, including residents, local authorities, NGOs, and businesses (van Westen, 2004). These committees can work together to develop and implement flood resilience plans tailored to the community's needs.

7. Promoting Nature-Based Solutions: Encourage community participation in nature-based solutions such as rainwater harvesting, green infrastructure development, and floodplain restoration. Engage residents in sustainable land use practices that reduce flood risks and enhance ecosystem resilience.

8. Sustainable Infrastructure Planning: Ensure that infrastructure development considers long-term sustainability and resilience to floods. This includes designing and building roads, bridges, and public facilities that can withstand flood impacts and incorporate environmentally friendly materials and techniques.

9. Good Governance and Policy Implementation: Effective governance and policy implementation are crucial for achieving sustainable flood risk management. Local authorities should develop and enforce policies that promote sustainable land use, construction standards, and community preparedness. Transparent decision-making processes and active community involvement are essential for building trust and ensuring the successful implementation of policies.

10. Understanding the Concept of Preparedness for Disaster Management Plans: Preparedness involves planning and implementing measures to mitigate the effects of disasters before they occur. This includes creating comprehensive disaster management plans that outline evacuation routes, emergency response protocols, and resource allocation. Regular drills and simulations can help communities' practice and refine their response to flood events.

11. Disaster Management Planning in Educational Institutions for Sustainable Development: Educational institutions play a vital role in fostering a culture of preparedness and resilience. Schools and colleges should incorporate disaster management training into their curricula, teaching students about flood risks, emergency response, and sustainable practices. Establishing disaster management committees within educational institutions can ensure a coordinated approach to preparedness and response.

12. Aligning Governance and Policy with Broader Educational Goals to Ensure Sustainability: Governance and policy should align with broader educational goals to promote sustainability. This includes integrating disaster risk reduction into national and local education policies, ensuring that students are equipped with the knowledge and skills to contribute to community resilience. Collaborative efforts between educational institutions, government agencies, and community organizations can create a comprehensive approach to sustainable development and disaster preparedness.

These sustainable suggestions and mitigation measures highlight the need for comprehensive flood risk management strategies that leverage both human-made interventions and natural processes to mitigate flood effects effectively and sustainably. By actively engaging the community in flood risk management efforts, fostering collaboration, and promoting sustainable practices, Thalappally Taluk can build a resilient and adaptive community that is better prepared to cope with and recover from flood events in a sustainable manner.

Policy Intervention

Flood risk management is a critical issue in Thrissur District, Kerala, requiring coordinated efforts across various governmental institutions. While the Kerala State Disaster Management Authority has established a comprehensive framework for disaster risk reduction, detailed in their Training Module on Disaster Risk Reduction for the Panchayat Department, there are significant gaps in the integration of these policies into the education system (Kerala Post Disaster Needs Assessment Floods and Landslides Report, August 2018). This module allocates specific responsibilities for different disasters from the state to the local level, ensuring proper administration among specialized bodies (Walia and Nusrat, 2020). However, despite these provisions, there is a lack of awareness among civilians about these institutions and their roles. The absence of basic disaster preparedness education in schools further exacerbates this issue, leading to underutilization of available resources. Addressing these gaps requires targeted policy interventions to enhance community resilience and ensure sustainable flood risk management.

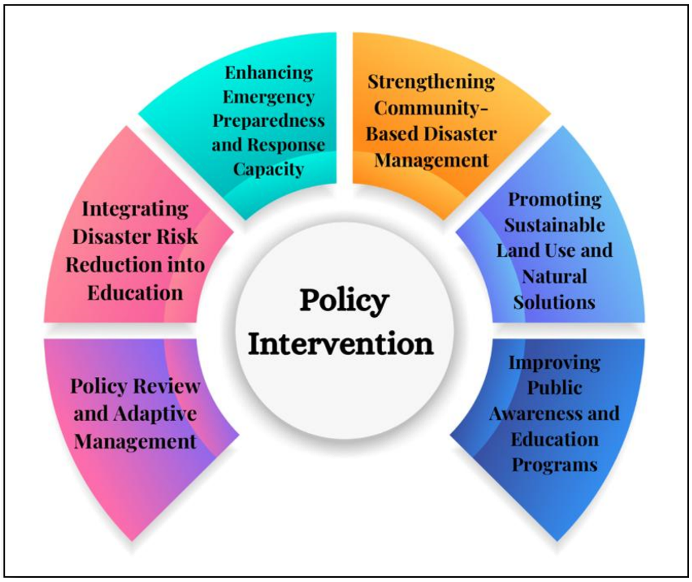


Figure 8: Key Policies

a) **Improving Public Awareness and Education Programs**

- **Objective:** Increase community awareness and understanding of flood risks and preparedness measures.
- **Intervention:** Develop and implement comprehensive public education campaigns that include workshops, school programs, and community meetings. These programs should cover flood risk awareness, emergency response procedures, and the importance of sustainable practices.
- **Implementation:** Partner with educational institutions, NGOs, and local governments to design and deliver these programs. Utilize local languages and culturally relevant materials to enhance engagement and effectiveness.

b) **Promoting Sustainable Land Use and Natural Solutions**

- **Objective**: Reduce flood risks through sustainable land use planning and the preservation of natural ecosystems.
- **Intervention:** Implement land use policies that prevent construction in high-risk flood zones and promote the restoration and conservation of natural floodplains, wetlands, and mangroves. Encourage practices such as rainwater harvesting and the creation of green spaces.
- **Implementation:** Develop and enforce zoning regulations that restrict development in vulnerable areas. Collaborate with environmental organizations and local communities to restore and maintain natural habitats.

c) **Strengthening Community-Based Disaster Management**

- **Objective:** Empower local communities to take an active role in disaster management and resilience building.
- **Intervention:** Establish community resilience committees that include representatives from diverse sectors such as residents, local authorities, businesses, and NGOs (Joseph et. al., 2018). Provide training and resources to these committees to develop and implement local disaster management plans.
- **Implementation:** Facilitate regular meetings and workshops for these committees to share knowledge and coordinate efforts. Secure funding and technical support from government and international agencies.

d) **Enhancing Emergency Preparedness and Response Capacity**

- **Objective:** Improve the community's capacity to respond effectively to flood events.

- **Intervention:** Conduct regular emergency drills and simulations to test and improve response plans. Equip local emergency services with the necessary tools and resources to handle flood emergencies.
- **Implementation:** Coordinate with disaster management authorities to plan and execute these drills. Invest in training programs and the procurement of essential equipment for first responders.

e) Integrating Disaster Risk Reduction into Education

- **Objective:** Foster a culture of preparedness and resilience through education.
- **Intervention:** Integrate disaster risk reduction (DRR) into school curricula and extracurricular activities. Encourage educational institutions to develop DRR plans and conduct regular safety drills.
- **Implementation:** Collaborate with the Department of Education to incorporate DRR into the curriculum. Provide training for teachers and school administrators on how to effectively deliver these programs.

f) Policy Review and Adaptive Management

- **Objective:** Ensure that flood risk management policies remain effective and relevant.
- **Intervention:** Establish a framework for the regular review and updating of flood management policies based on new data, scientific advancements, and community feedback.
- **Implementation:** Create a task force comprising government officials, scientists, and community representatives to oversee policy review and recommend changes as needed.

Implementing these policy interventions can significantly enhance flood risk management and community resilience in Thrissur District. By combining technological advancements with community engagement and sustainable practices, these policies can help build a more resilient and adaptive community capable of effectively managing flood risks and minimizing their impacts.

Conclusions

The study on flood risk management and community resilience in Thrissur District, Kerala, offers valuable insights into the challenges faced by the community during flood events and proposes sustainable solutions to enhance resilience and long-term sustainability. These findings underscore the need for a comprehensive approach that integrates sustainable practices, effective governance, community engagement, and innovative solutions to mitigate the adverse impacts of floods.

The study highlights a significant awareness and knowledge about floods among the community, particularly within the younger demographic, indicating the success of existing disaster management training programs. However, it also identifies gaps in preparedness, communication, and infrastructure that must be addressed through targeted education and training, improved communication strategies, and the development of resilient infrastructure. Involving community members in monitoring flood risks and establishing early warning systems is crucial. The formation of community resilience committees can facilitate the development and implementation of tailored flood resilience plans. Promoting nature-based solutions and sustainable infrastructure planning further strengthens the community's capacity to withstand flood events.

Good governance and effective policy implementation are pivotal for sustainable flood risk management. Transparent decision-making processes, active community involvement, and aligning governance with broader educational goals are essential for building trust and successfully implementing sustainable practices. Integrating disaster risk reduction into educational curricula fosters a culture of preparedness and resilience among students. Sustainable infrastructure planning should prioritize designing buildings and public facilities to withstand flood conditions. This includes using flood-resistant materials, elevating structures in flood-prone areas, and incorporating flood-proofing measures to minimize damage and disruption during flood events. Additionally, promoting nature-based solutions such as rainwater harvesting, green infrastructure, and floodplain restoration can enhance ecosystem resilience and reduce flood risks.

In conclusion, the study underscores the need for a holistic approach to flood risk management that combines human-made interventions with natural processes, leverages community engagement, and promotes sustainable practices. By adopting these strategies, Thrissur district can enhance its flood resilience, mitigate the impacts of flood events, and move towards a sustainable and adaptive future.

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ESTIMATION OF SPATIO-TEMPORAL EXTENT OF FREE-FLOATING AQUATIC PLANT PISTIA STRATIOTES IN PARTS OF SUBARNAREKHA RIVER COURSE USING REMOTE SENSING

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ABSTRACT

Rivers serve as a vital water resource, fulfilling multi-facet requirements such as for drinking purpose, irrigation, fish farming etc. Lotic water bodies like river provides congenial ecological niche to promote growth of varied aquatic plants including water hyacinth, *Eichhornia crassipes* and *Pistia stratiotes*. This study aims to estimate the spatio-temporal growth and spread of the free-floating aquatic plant *Pistia stratiotes* on the water surfaces of the Subarnarekha River and Getalsud Reservoir near Ranchi city. These plants float freely on the water surface, estimating their exact extent through physical surveys alone is challenging. Remote sensing serves as a valuable tool, offering time-specific, synoptic views of the entire area. The present study emphasizes the integration of physical surveys with remote sensing techniques to estimate the surface coverage of free-floating aquatic vegetation. Our findings indicate that *Pistia stratiotes* exhibits an increase in surface coverage from October 2022 (autumn) to April 2023 (early summer) over study area. A declining trend in surface coverage is observed after April, 2023 (summer), coinciding with increased temperature condition, limited surface water availability, underscores the importance of effective water resource management for sustainable urban living. The study shows vulnerability of freshwater to exotic aquatic plant growth and attempts to establishes a method to estimate spread of aquatic plant, rate of vegetative growth over water surface.

Keywords: *Remote Sensing and GIS, Pistia stratiotes, aquatic plan*t, *Subarnarekha River, Ranchi, Urban sustainability, Drinking water supply*

Introduction

Water is an indispensable natural resource for all the living organisms whether aquatic or terrestrial ones. The land-dwelling organisms largely depend upon the freshwater resources for their day-to-day activities and we humans are no exceptions. Only about 0.3% of the global

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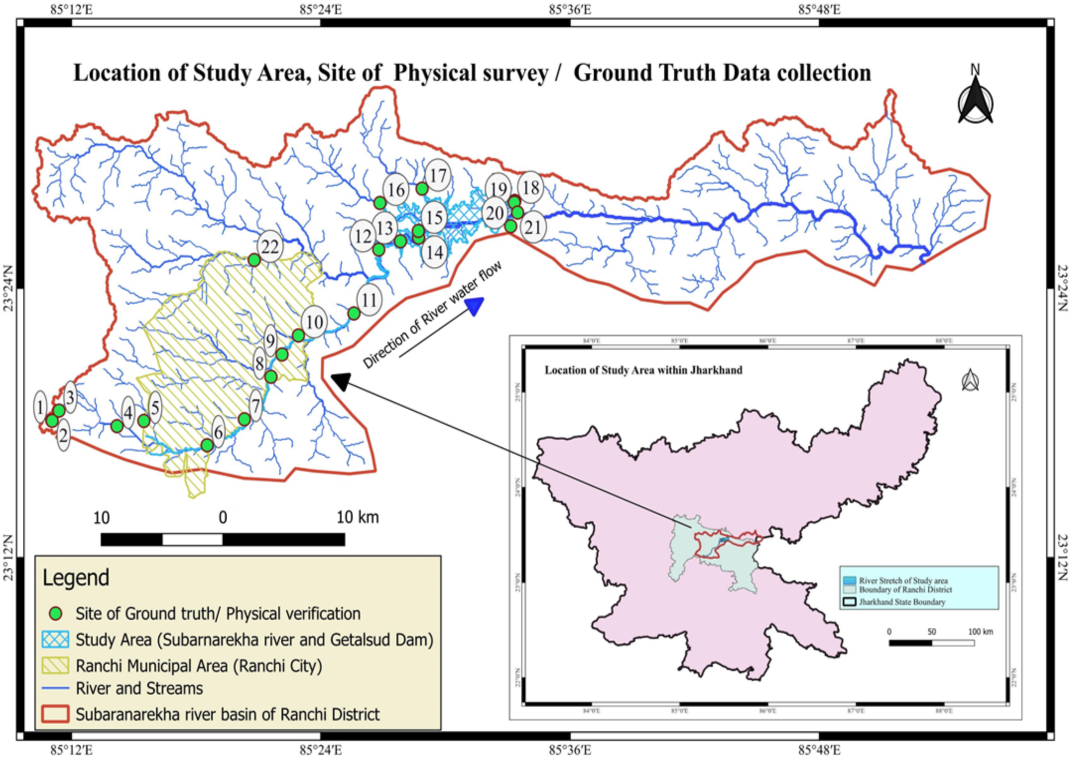
water resources are usable by the human population. There is remarkably high shortage of adequate drinking water supply, affecting more than one billion people across the globe (Kılıç, 2020). “The water hyacinth is categorized among the world's top ten worst invasive plant species of aquatic ecosystems” (Churko, Nhamo and Chitakira, 2024). “Aquatic plants are considered as weeds because of their capability to grow in eutrophic water bodies and pose a potential threat to fish productivity and recreational activities” (Reddy and Debusk, 1984). “Ecologically, water hyacinth can impact zooplankton and phytoplankton productivity in freshwater ecosystem, modify surface water clarity and cause hypoxia or a decrease in the concentration of related nutrients and contaminants, such as nitrogen, phosphorous and heavy metals” (Thamaga and Dube, 2018). *Pistia* is one of the free-floating aquatic hyacinth plant (Kabir, et al., 2023). Locational and temporal extent is important to understand the phenomena properly, particularly its direction of spreading and rate of growth, whether it is a plant or some weather event. “A spatiotemporal ….should depend on what we know about the natural variable it represents, as well as how we know it” (Christakos, 2000). Majority of water requirements of Ranchi city is fulfilled by Subarnarekha river and its tributaries. The change in the physiochemical and biological parameters of the river water greatly influences the quality of the water supply not only for human consumption, animal husbandry, and the industrial use but also affects the survival of the aquatic organisms inhabiting the river water (Omer, 2020). It is a common observation that from early spring to summer there is luxuriant growth of water weeds such as papyrus (*Cyperus papyrus*), water hyacinth (*Eichhornia crassipes*), Kariba weeds (*Salvinia molesta*), alligator weed (*Alteranthera philoxeroides*) (Gordon, et al., 2013), which even continues till monsoon period. *Pistia* grows well in dry period and even in low solar radiation (Aoi and Hayashi, 1996). Most of the open water zone is covered with the blanket of these aquatic macro-hydrophytes. This has substantial negative impacts on the physiochemical and biological parameters of the water body, hydrology, aquatic ecosystem (Milićević, 2023). Remotely sensed data requires an accurate representation of spatial variability by ground truth data (Salas , Subburayalu , et al., 2021) Thus, this paper has the societal relevance with respect to its health, economy, and environment and highlights the importance of UN SDG 3, SDG 8, 13, SDG14 and SDG 15. Ranchi become million city (a city having population above one million) in the census year 2011 (Census 2011). City is growing in its size both in terms of geographical area and population after becoming state capital city of Jharkhand on 15th Nov, 2000. In field survey we interacted with local residents of nearby villages. They claimed they have witness the arrival of this weed for the first time in the year 2023 to this area. Therefore, extimation of spatio-temporal extent of the weed is significant step to understand river water health.

Study Area

River Subarnarekha originates from Ranichua near Nagari, Ranchi and flows through the states of Jharkhand, Orissa and West Bengal finally drains into the Bay of Bengal (Kumar, 1970) (Sinha and Singh, 2003). The flow of river and its tributary being embarked by the construction of several dams along its course such as Hatia dam, Getalsud dam and Kanke Dam for drinking water supply to Ranchi city, water supply to industrial network in and around Ranchi, generation of hydel power and other activities (Anonymous, 2010).



Source : *Prepared by Author*

Figure 1 : Location of Physical survey and Ground Truth Data / Water Sample Collection

The catchment area of these dams varies with the season, shrinking in summer and widening during and after monsoon. For present study Subarnarekha river stretch of about 42 km from its origin (site-01 in Figure- 01), near Pandu Village, Nagari to Getalsud Dam in Ranchi district is taken as study area.

River Subarnarekha flows through the southern and south-eastern margin of Ranchi city (Ranchi municipal corporation area). Towards nearly 15 kms northeast of the city center Getalsud Dam is situated on river Subarnarekha to supply drinking water to the city. West of Getalsud dam several smaller tributaries also joins Subarnarekha river such as- Hinoo/Doronda river, Harmu river, Chadri Nala, Jumar river, Sapahi river, and Doma River.

Methodology

Mapping of vegetation cover using satellite imagery is very much reliable and established method to find out real scenario of vegetative growth of water lattice at particular position on given time frame (Thamaga and Dube, 2018). Satellite remote sensing technology includes the access of archive of satellite imagery datasets for earlier time periods. Although satellite image has many advantages but few limitations are also associated with it such as, spatial resolution, availability of cloud free data, temporal repeat interval period etc. are significant.

Two approaches are mainly used in remote sensing image classification technique. These are by using raster based supervised or unsupervised classification and another by using vector based visual method. However, both methods have their own advantage and disadvantage but Vector approach is more precise, hence chances of misclassification of other land use land cover feature is avoidable with proper ground survey and field truth verification. Nearby dam area there is Spring paddy cultivation which was sown in the month of Jan/Feb and harvest in the month of May or early June. To remove all other types of vegetation apart from *Pistia*, vector-based approach along with physical survey was used to map the extent of *Pistia* growth.

This study estimates the growth of *Pistia* from the period of October 2022 (post monsoon period) to May 2023 (pre-Monsoon Period). Throughout the study number of site were taken for careful physical observation, ground truth and water sample collection. Careful Visual Classification using keys of visual image interpretation is very significant such as - texture, colour, shape, size, and association. Paddy also have similar colour, but in terms of texture *Pistia* is smooth whereas paddy fields or vegetable farming gives rough texture. We have used Garmin GPS to collect location of ground truth and sample sites. In ground truth we have physically observed the features, photography for plant identification. Site for ground truth data and water sample were selected by considering the road proximity to confluence of smaller stream/river with Subarnarekha River. Most sites are river bridges which are also cremation sites (table-3). Samples were taken about 100-200 meter upstream from cremation sites near the bridges. River of the area is only few meters wide and it is not very deep as well. Samples were taken in middle of river wherever it was possible. Database comprises open and free satellite imagery of the area (table-1). QGIS was used to map the extent of *Pistia*.

Table 1: Database of satellite imagery

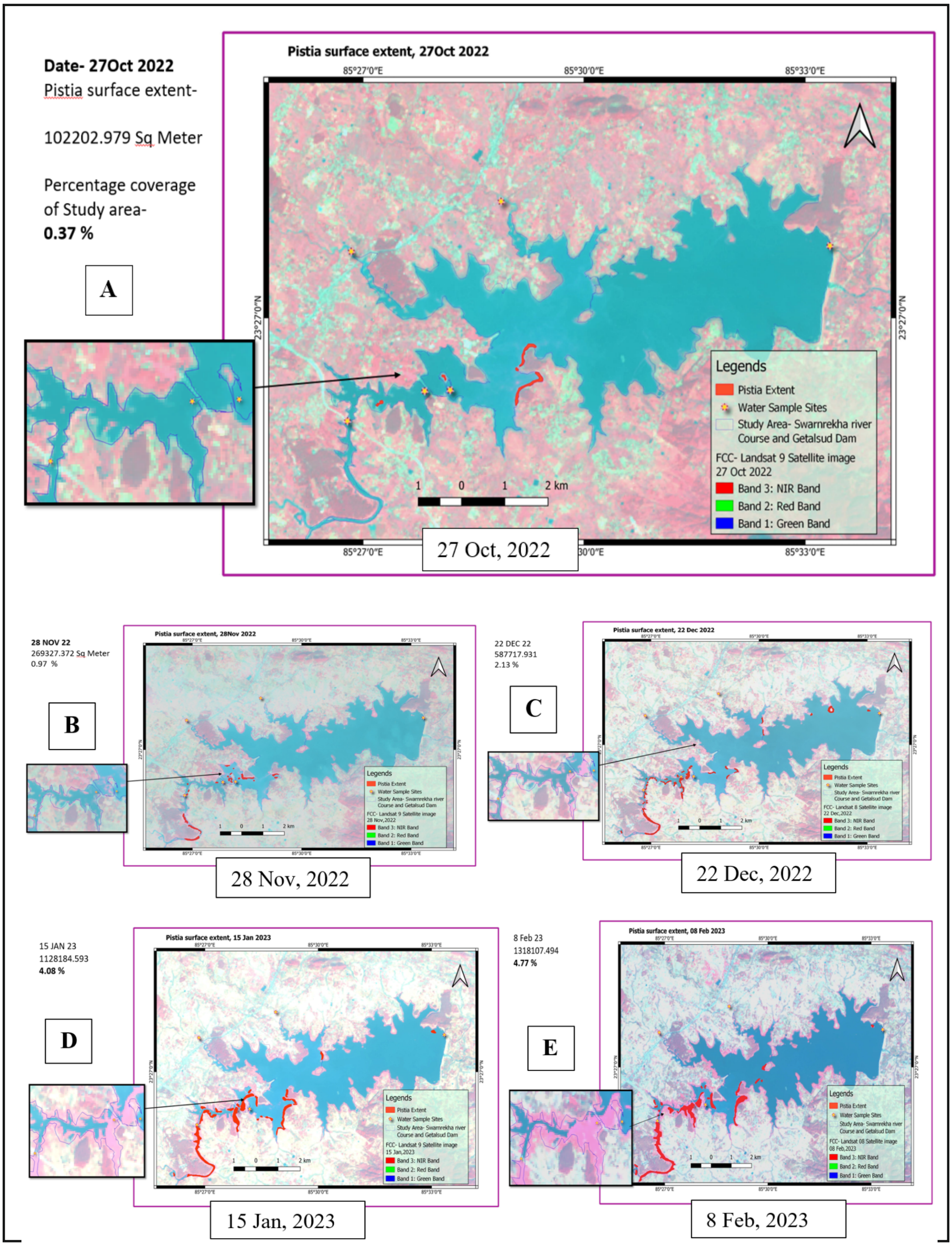
Satellite Mission	Date of Imagery	Temporal Resolution
Landsat 9	27 OCT 2022	-
Landsat 9	28 NOV 2022	32
Landsat 8	22 DEC 2022	24
Landsat 9	15 JAN 2023	24
Landsat 8	8 Feb 2023	24
Landsat 9	4 March 2023	24
Landsat 8	28 MARCH 2023	24
Landsat 8	13 APRIL 2023	16
Landsat 9	7 MAY 2023	24
Landsat 9	23 MAY 2023	16

Source : *Prepared by Author*

Along with the ground truth data collection for some physio-chemical properties of water were also analyzed which includes- pH, TDS, EC and salinity. Research questions were formulated for the studies. Research question includes is there any spatial-temporal difference in pH, EC values are found along the river stretch or not. These parameters were analyzed on the site using pen-type pH-TDS meter (Extech EC-500) after proper calibration. Some water samples (300 ml-BOD bottle) were collected at selected sites for testing Dissolve Oxygen (DO), and BOD estimation. Estimation of BOD and COD done through titration method.

Using satellite imagery, supplemented with physical surveys and ground truth data, the spread of Pistia was mapped during October 2022-May 2023 (Table 1). The species exhibited noticeable growth and proliferation in certain parts of the Rukka-Getalsud Reservoir from October 2022 (post-monsoon) to March–April 2023 (pre-monsoon).

Result and Discussion



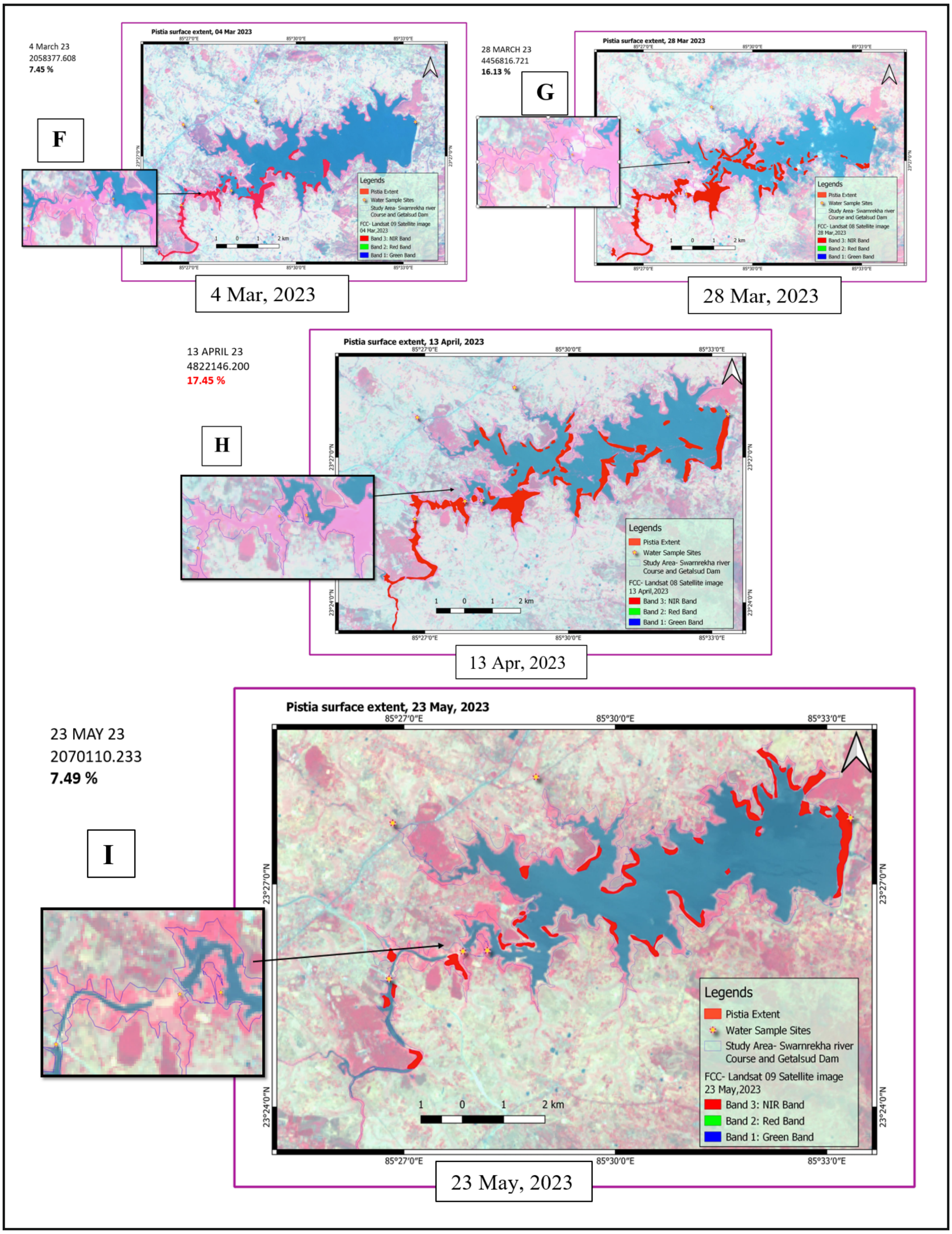


Figure 2 : Growth of Pistia seen in the satellite imagery (27th Oct 2022 to 23rd May 2023

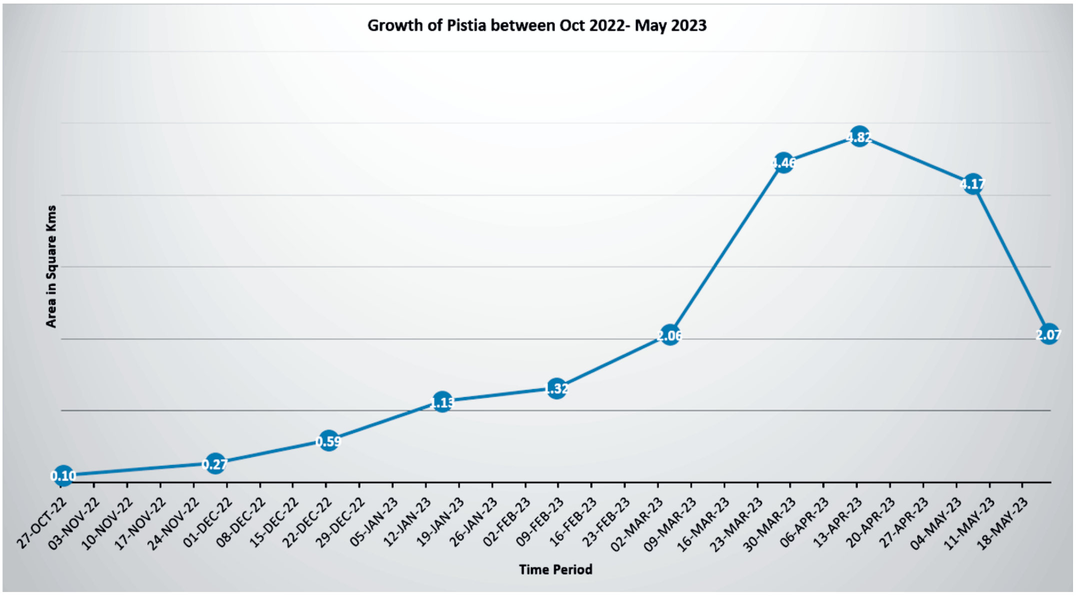
Figure 3 : Luxuriant growth of Pistia in Getalsud Dam area in the month of January, 2023

Figure 4 : Mass decaying of Pistia in Getalsud Dam area in the month of May, 2023

Table 2 : Assessment and estimation of area coverage by *Pistia*

SATELLITE MISSION	DATE OF IMAGERY	Temporal Resolution	Area Square meter	Area Square km	Area covered by pistia (in % of total study area)
Landsat 9	**27 OCT 22**	**-**	**102202.979**	**0.102202979**	**0.37**
Landsat 9	28 NOV 22	32	269327.372	0.269327372	0.97
Landsat 8	22 DEC 22	24	587717.931	0.587717931	2.13
Landsat 9	15 JAN 23	24	1128184.593	1.128184593	4.08
Landsat 8	8 Feb 23	24	1318107.494	1.318107494	4.77
Landsat 9	4 March 23	24	2058377.608	2.058377608	7.45
Landsat 8	28 MARCH 23	24	4456816.721	4.456816721	16.13
Landsat 8	**13 APRIL 23**	**16**	**4822146.200**	**4.8221462**	**17.45**
Landsat 9	7 MAY 23	24	4168061.192	4.168061192	15.08
Landsat 9	23 MAY 23	16	2070110.233	2.070110233	7.49

Source : *Computed by Author*



Source : *Computed by Author*

Figure 5 : Growth of Pistia between October 2022 to May 2023

Ground surveys were conducted twice, once in January 2023 and again in May 2023, to validate the observations. After May, *Pistia* began to decline and decay significantly, coinciding with the peak summer season when daily maximum temperatures typically exceeded 40°C (Figure 2 & 4). The total area of the study area is 27636518.497 square meters that is 27.636 km^2(Table-2).

In this study trend of growth and decline of *Pistia* over the time period was observed very clearly (Table-2 and Figure-5). According to local villagers (Turup- nearby village), the free-floating plant of *Pistia stratiotes* reached at these sites through floating water and start growing which replaced *Eichhornia crassipes*. It was first seen in the river in Autumn months of 2022. During our physical survey we found that *Pistia* has dominated and pushed the *Eichhornia* to margin. *Pistia* growth was maximum in first half of the April month. From second half of the April month Pistia started to decline. This is likely due to intolerance to very high temperature in the area (above 35ºC, maximum 42ºC), declining water level, depletion of nutrient resources and intense intraspecific competition. At the end of May month *Pistia* was found in highly degraded form in Getalsud dam area (Figure 4). During monsoon period most of the plants flushed with increased river water to other areas, later in the month of August *Eichhornia crassipes* again took over the areas earlier dominated by *Pistia.*

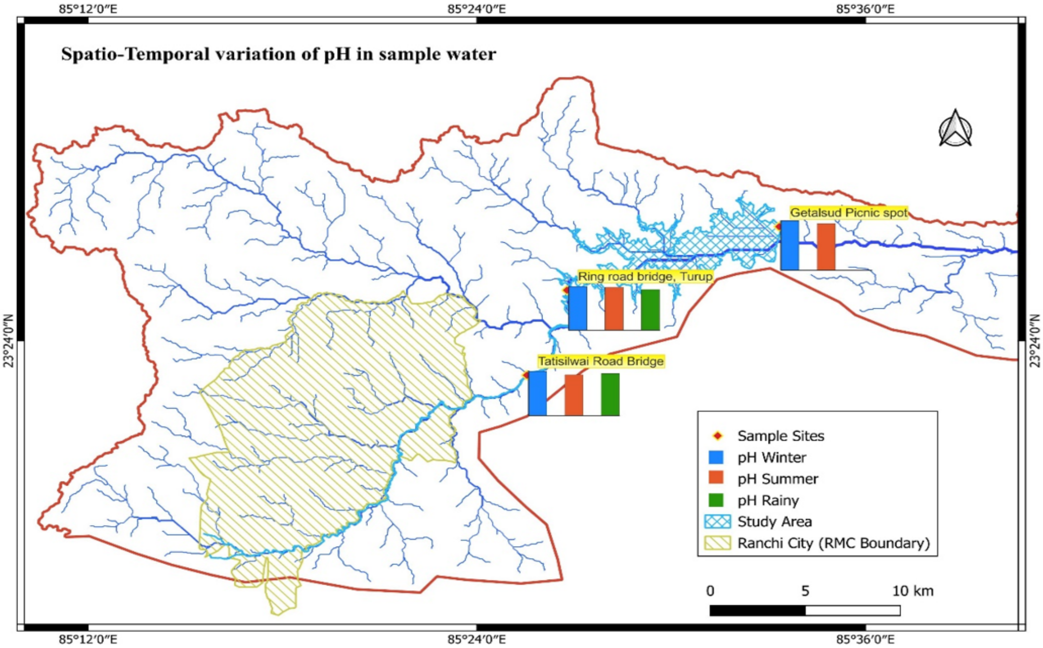
Some physio-chemical parameters were also recorded during the study (table-3). The pH variation can be noted in the river course of selected site by using sensor-based pH meter. The small variation was seen at different selected site. The pH range variation is observed seasonally and spatially. pH temporal variation can be noted at Tatisilwai road bridge which was 7.7 in winter month of January 2023 while it was 7.1 in summer month of May 2023, and it was 7.3 in rainy month of August 2023 (site no-11; Table -3). Higher pH ranges were observed at Getlsud Picnic Spot that was 8.56 in the month of January, 2023 (site no-18; Table-3). At the same spot in the month of May, 2023 (site no-18; Table-3) it was 8.1. High pH in winter season and lower stretch of the river is associated with high photosynthesis by aquatic plants, Industrial discharge, fertilizer rich agricultural runoff, waste water treatment etc. Slight pH decreased in the summer month of the same spot can be associated with mass decaying of Pistia.

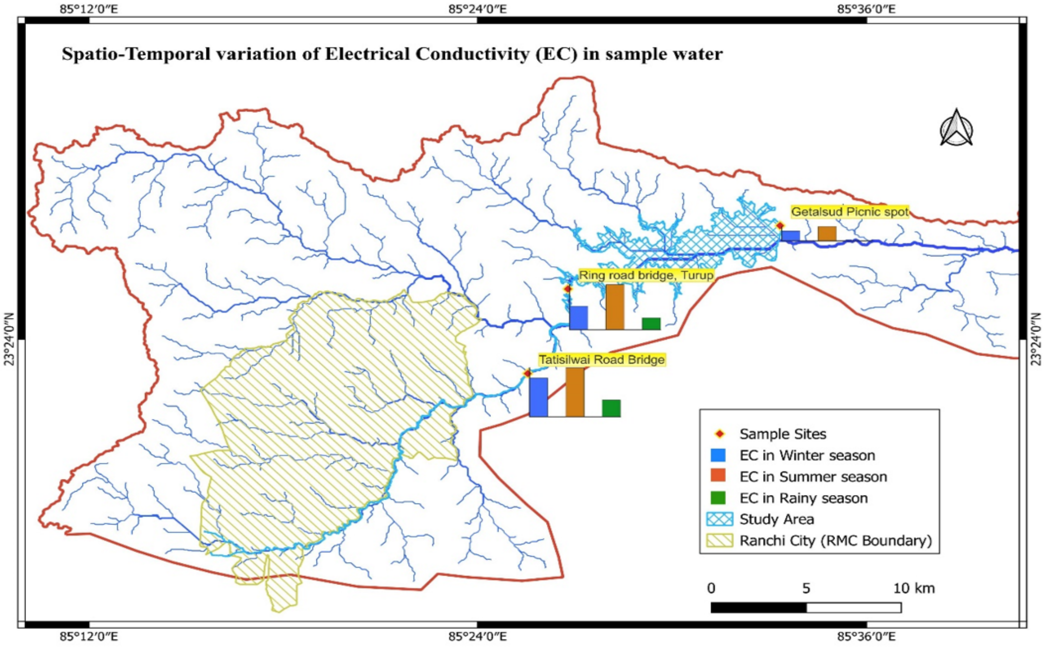
Table 3: Physio-chemical parameters of the river Stretch

Date	Sample Site no.	Place Name	pH	EC (µS)	TDS (in ppm)	Salinity	Temp (at site)	BOD (mg/ ml)	COD	BOD: COD Ratio	DO
7/24/2022	01	Rani Chua (Origin of Subarnarekha)	7	79	51.35	37	26	2.4	25.6	0.093	na
1/15/2023	9	Chutia-bridge	7.4	720	468	338	19.6	29.2	15.2	1.92	2.4
1/15/2023	10	Chadri bend	7.7	870	565.5	422	19.3	33.6	15.68	2.14	2
1/15/2023	**11**	**Tatisilwai Road Bridge**	**7.7**	949	616.85	466	20.7	35.6	18.88	1.88	2
1/15/2023	12	Ring road bridge, Turup	7.6	580	377	259	22.2	4.4	22.4	0.19	2
1/26/2023	15	Rukka dam pipe line right side	7.8	306	198.9	138	27.5	4	17.6	0.22	8
1/26/2023	**18**	**Getalsud Picnic Spot**	**8.56**	243	157.95	110	23.6	0.8	14.4	0.055	2.8
1/26/2023	19	Getalsud dam inside 156 m off dam side	8.53	248	161.2	118	22.6	2	12.8	0.15	2.8
5/28/2023	**18**	**Getalsud Picnic Spot**	**8.1**	352	228.8	176	37.2	0.4	6.4	0.06	3.6
5/28/2023	12	Ring road bridge, Turup	7.5	1105	718.25	552.5	32	3.2	16	0.2	4
5/28/2023	**11**	**Tatisilwai Road Bridge**	**7.1**	**1201**	780.65	600.5	31.2	2.8*	24	0.11	2.8
5/28/2023	13	Subarnarekha Bridge Getalsud Inlet	7.2	1034	672.1	517	29.7	na	na	na	na
8/26/2023	**11**	**Tatisilwai Road Bridge**	**7.3**	**413**	268.45	206.5	28.6	2	na	na	4.4
8/26/2023	12	Ring road bridge, Turup	7.06	292	189.8	146	29.2	2.2	na	na	5.2

Source : *Computed by Author*

Spatio-Temporal Changes in pH and EC-





Source : *Prepared by Author*

Figure 6 : Spatio-Temporal Changes of pH and EC along the river and dam area

Temporal Changes in pH and EC

Temporal (Seasonal) changes in water parameters

Tatisilwai Road Bridge (site no-11)-

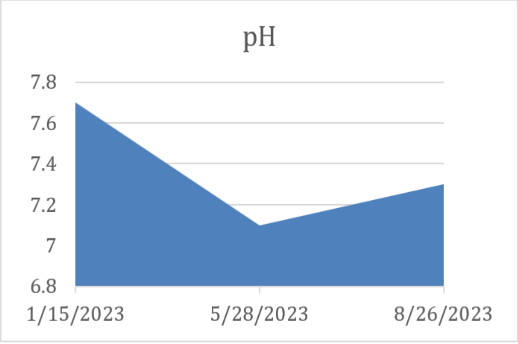


Figure 7 : Temporal Changes in pH

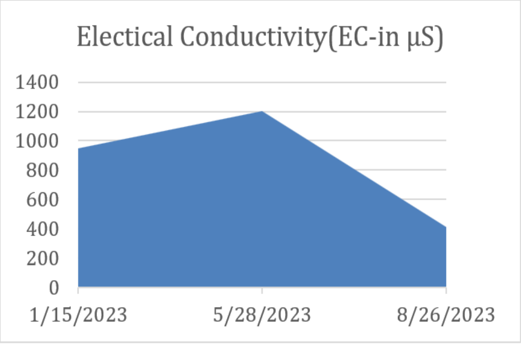


Figure 8 : Electrical conductivity

Similarly, Electrical Conductivity (EC) and TDS were also measured by using sensor-based electrodes. The low value of EC, 79 ppm and TDS, 51.3 ppm at Rani Chua (origin of Subarnarekha River) while high value of EC, 1201 ppm and TDS, 780 ppm at Tatisilwai road bridge was observed (Table-03). While in other spots the value of EC varies between 200 ppm to 1000 ppm while TDS varies from 150 ppm to 800 ppm in range. The relatively high value of EC and TDS at Tatisilwai road bridge indicate that these areas are filled with high amount of suspended organic matter. The sample water temperature was little bit high of 37^{o}C in month of May (summer) and comparatively low of 19^{o}C was reported during winter samples collection. The low salinity index of 37 ppm at Rani Chua but high value of 600 ppm was measured at Tatisilwai road bridge. The high value of EC, TDS and Salinity at Tatisilwai road bridge shows that these areas are highly polluted from organic matter. Tatisilwai road bridge is most polluted in our observation (Site-11, Table-03 and Figure-06). The suspended organic matter probably driven from densely populated area along the course of river. These organic matters may concentrate and accumulated in ground area due to water evaporation during summer. Further more careful studies required to understand the underlaying factors.

BOD and COD are indicators of water pollution. BOD express the presence of bacteria in water. High bacteria presence causes high BOD value. Higher bacteria are found in water rich in organic and inorganic substances. It provides food and nutrition to these microorganisms. Domestic and municipal waste affluence are discharged in the water of the river. To certain length and stretch of the river bacterial presence is high after few kilometers its presence is significantly reduced.

Ecological hazards due to its luxuriant growth and mass decaying

The luxuriant growth of *Pistia stratiotes* possess a great threat to the socio-economic, environmental and health aspects. Dense mat of *Pistia stratiotes* reduces the water flow in drainage and irrigation canals, also blocs the fishing and boating activities of the tourists, adversely hampering the livelihoods of the fishermen and boatmen who depend upon the water bodies for their bread and butter. The blocking of water flow greatly disrupts the production of hydropower electricity (Dray and Center, 2002).

Due to its invasive nature and high biotic potential, it becomes superior competitor thereby posing a threat to native species, thus also contributing to the biodiversity loss of the water bodies. The water covered areas *Pistia stratiotes* show preferred development environments and breeding ground for different species of mosquitoes and the larvae of *Culex, Anopheles* and *Mansonia*. Thus promoting the spread of deadly diseases like of malaria, filariasis and encephalomyelithes etc (Lounibos and Dewald, 1989).

Limitation- This study faced some of the challenges and limitations. Ground truth and sample collection in the field is not easy task, often there is no approach pathway to collect the samples. In general, in India and more particularly to the study area river bridges are the place of cremations, such places are often not clean and unpleasant. Collecting sample from such sites are challenging. Sample handing, transportation, storage, and analysis is another challenges.

Recommendation- This study raises question on how these vital water resources are monitored, and action are taken or not taken. Authors wish to recommend for timely monitoring of fresh water resource which are key to drinking water supply to thousands of households and other creatures depending on it. A carefully planned future studies is significant to investigate and find out spatial changes in the water quality parameters, driving factors responsible to rapid growth of such plants, and its possible consequences on quality of drinking water supply.

Conclusion

Our observations reveal an expansion in the surface coverage of *Pistia stratiotes* from October 2022 (autumn) through April 2023 (early summer) across the study area. Post-April, a noticeable decline in coverage is evident, correlating with elevated temperatures, intensified evaporation, and diminished river water levels. The rapid growth of *Pistia stratiotes*, followed by its mass decay, contributes to adverse conditions for supply of drinking water during peak summer months, resulted in rationing, failure of water supplies in the city on certain occasions. The discharge of effluents without proper treatment leads to contamination of water bodies with organic and inorganic contents.

Acknowledgement- *We wish to thank NRSC, USGS for maintain depository of satellite imagery through which we can freely access to satellite imageries for research and study purposes. We extend our sincere gratitude towards Society of Earth Observation and Conservation (SEOC), SXC. A society of multi-disciplinary study at St. Xavier's College, Ranchi*.

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URBANIZATION AND SLUM POPULATION TRENDS IN THE JAMSHEDPUR URBAN AGGLOMERATION: A COMPARATIVE SPATIO ANALYSIS

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ABSTRACT

Jamshedpur urban agglomeration, a major industrial city in Jharkhand, has witnessed a process of urbanization driven primarily by industrial development. Between 1911 and 2011, the region witnessed a steady increase in urban population, while the pace of residential development has not kept pace with the needs of the lower income and migrant population, particularly the lower income groups. This imbalance has led to the spontaneous growth of slums in the Jamshedpur urban agglomeration. This study is based on the 2001 and 2011 census data and aims to analyse the spatial and statistical relationship between urbanization and slum population in the Jamshedpur urban agglomeration. The study analysed the spatial distribution of slums using Google Earth Pro, while statistical tests were conducted using Paired Sample T-Test and Scatterplot with the help of Jamovi software. The T-Test showed that the difference between urban and slum population is statistically significant, while the Scatterplot showed a negative correlation between the two. This trend indicates that while planned redevelopment, Pradhan Mantri Awas Yojana, and infrastructure provided by JUSCO have led to a decline in slum population, the trend has not been uniform across all areas—Mango NAC has seen an increase in slum population, indicating regional disparities. This study establishes that the change in slum population is not just numerical but is a result of socio-economic, policy, and spatial interventions, highlighting the need for inclusive urban planning.

Keywords: *Industrial Development, Jamshedpur Urban Agglomeration, Slum Population, Slum Redevelopment, Urbanization.*

Introduction

In every era of human history, cities have been centers of civilization and culture (Singh ,2020). Today, 54 per cent of the world's population lives in urban areas, a proportion that is expected to increase to 66 per cent by 2050. Projections show that urbanization combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, with close to 90 percent of the increase concentrated in Asia and Africa (UN-DESA, 2014). In 1950, 30 percent of the world's population was urban, and by 2050, 66

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percent of the world's population is projected to be urban. The urban population of the world has grown rapidly since 1950, from 746 million to 3.9 billion in 2014. Asia, despite its lower level of urbanization, is home to 53 percent of the world's urban population, followed by Europe (14 percent) and Latin America and the Caribbean (13 percent). Continuing population growth and urbanization are projected to add 2.5 billion people to the world's urban population by 2050, with nearly 90 percent of the increase concentrated in Asia and Africa. Just three countries- India, China and Nigeria, together are expected to account for 37 percent of the projected growth of the world's urban population between 2014 and 2050 (Slum in India,2015). Today more than half the world's population, over 4 billion people, live in cities. The urban population is expected to more than double by 2050, by which time nearly 7 out of 10 people will live in cities. Cities must meet the growing global demand for more and better jobs, efficient infrastructure and services, and affordable housing, especially for the more than one billion people living in slums or informal settlements. Pressure on cities is further increased by rising rates of global conflict, with more than half of forcibly displaced people living in cities and urban areas (world bank urban development overview, 2025).

The population in metros is increasing at a rapid pace, but residential houses are not built in proportion to the increasing population. Thus, generally one-fourth to half of the urban population is forced to take shelter in slums, road tracks, railway stations, etc (Singh and Maurya, 2020). Slums live on the outer boundary of the central business area of the city. The condition of slums depends on the physical, social and economic factors of the houses there. The functional characteristics of the city in those areas get worse day by day. It is found in almost all the cities of the world, but many such areas develop in old cities and industrial cities (Sinha and Bala, 2018).

Industrialization, rural-urban migration, development of services, etc. are the main factors accelerating the process of urbanization. These factors have contributed significantly to the urbanization of various developed and developing countries of the world. This urbanization has led to slums being found in some form or the other in almost all the metropolises of the world. The problem of slums is not limited to developing countries only, but such housing problems are also found in the metropolises of many developed countries. There is a very close and high-level positive correlation between industrialization and urbanization. In developed countries, industrialization has been the main promoter of urbanization. In Britain, the pace of both industrialization and urbanization had increased due to the development of modern road transport even before the twentieth century. Thus, by the beginning of the twentieth century, 80 percent of Britain's population started living in cities. There has been no significant change in the level of urbanization in the years thereafter. In England, foreign black people live in the old parts of various cities where the houses have become very old and dilapidated. According to an estimate, 20 percent of residential houses in Manchester and

Birmingham and 30 percent in Hull are very old and worth demolition, where the low-income group population has taken shelter. Similarly, in London's Wilden and Bixton Nottinghill areas, 100 to 150 year old and dilapidated houses are found, which have taken the form of slums. The development of modern cities in Europe is mainly the result of industrialization. Wherever factories related to various industries were established, cities sprang up there. A large number of people from the nearby rural areas were attracted to the cities to work in the factories established in the cities and settled there. On one hand, in Paris, the most beautiful city in the world, one can see modern multi-storey grand buildings. On the other hand, in some parts of the city, low-level settlements of poor people are also found which can be placed in the category of slums. The high-level urbanization found in developed countries like the United States of America can be said to be the result of the advanced industrialization there. Similarly, in many metropolises of the United States like New York, Chicago, Birmingham, Detroit, San Francisco etc. where there are settlements of Negro people, the rent of houses is low but repair of houses, cleanliness, parks and general public facilities are often neglected. Slums are also found in some parts of Rome and Naples which are mainly located inside the city and behind the central business area. In the city of Bahia in Brazil, low income group people coming from rural areas have made their residence on the Pilurinho hill. Social evils like tuberculosis and prostitution are said to be at their peak in this slum. In India too, many cities were established and developed as industrial centers and industrialization has played a significant role in urbanization. But in India, urbanization is not a companion of industrialization like in western countries. Here, urbanization is happening rapidly even in the absence of industrialization. According to Peach (Gr.k. Peach), the aim of the policy makers of India was to industrialize without urbanization but urbanization happened without industrialization. The problem of slums has arisen as a result of urbanization in India. In India, about 20 percent of the urban population and about 30 percent of the metropolitan population lives in slums. According to the Census 1991, about 5 crore urban population of the country lived in slums (Singh and Maurya 2020).

Big cities like Ranchi, Bokaro, Jamshedpur, and Dhanbad are located in the state of Jharkhand, India, and have a high urban population. Before independence, the pace of urbanization in Jharkhand was slow, but it accelerated significantly after independence. Due to the mining industry, Damodar Valley Project, and Tata Steel Industry, several industries were established in this region, leading to the development of many urban centers. Cities like Jamshedpur, Ghatshila, Musabani, and Gua developed primarily because of the iron and copper mining industries (Tiwari 2019). Slums emerged in major cities of Jharkhand, with Jamshedpur, Adityapur, Ranchi, and Dhanbad being prominent examples. In Jamshedpur urban agglomeration, a decrease in total slum population and number of slums was observed in the 2011 Census compared to 2001—mainly in Jamshedpur Notified Area Committee (NAC) and

Adityapur Municipal Council. However, in Mango NAC and Jugsalai Municipality, the slum population and number of slums increased. This inconsistency highlights the unplanned nature of urbanization. It also reflects that in some parts of the industrial zones of Jamshedpur, slum development is ongoing due to industrial expansion and job availability.

So far, research has mostly focused on industrial development and urban expansion in Jamshedpur. But a detailed spatial study of slums, their population structure, and development is still lacking. This study aims to analyze the form and trends of urbanization in the Jamshedpur urban region and examine the relationship between urban population growth and slum population development. This research will be important for urban planning and understanding emerging slum patterns in growing urban centers like Mango and Jugsalai.

Objectives

1. To analyze the changes in slum population in the Jamshedpur Urban Agglomeration between 2001 and 2011.
2. To understand the impact of urbanization and spatial planning on slum areas.

Research Methodology

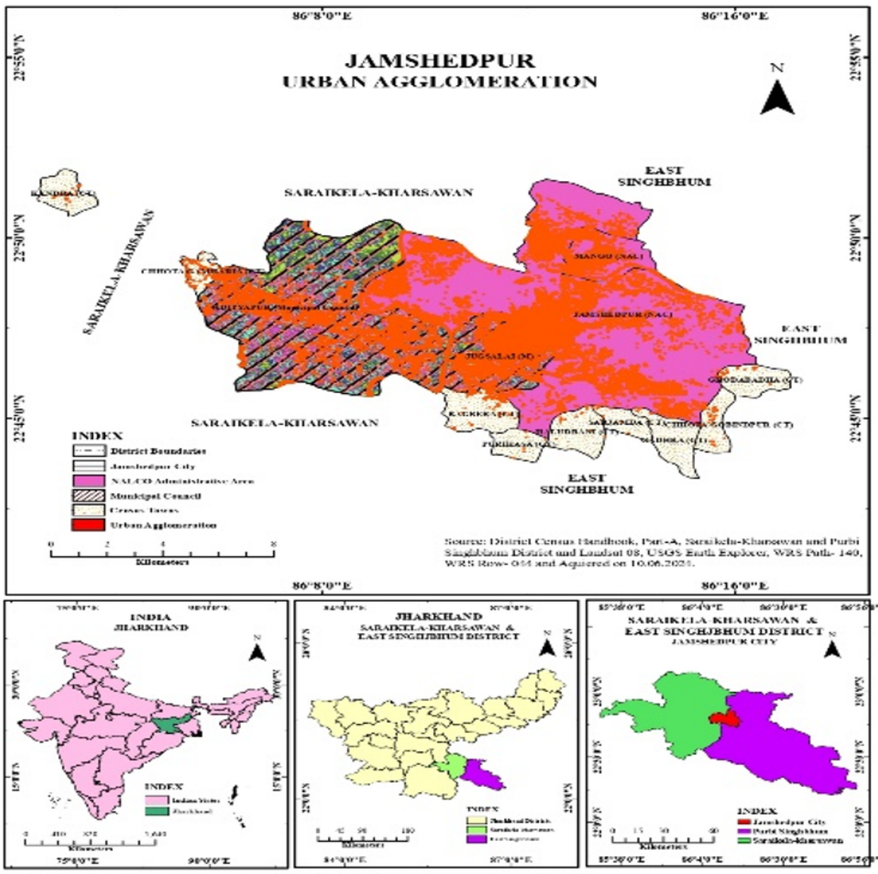
This study is mainly based on secondary data. To understand the trend of urban growth in Jamshedpur urban agglomeration, decadal data of urban population from Census of India 1911 to 2011 (Registrar General & Census Commissioner, India) was used. For detailed analysis of urban and slum population, data from Census of India 2001 and 2011, Series-21, Jharkhand, District Census Handbook was used. This data includes information on urban population, slum population, number of households living in slums and their percentage change over the decade. Additionally, information was collected from research articles, government reports and planning documents. Spatial analysis was carried out using Google Earth Pro, which helped in identifying the location, spread and proximity of slums in Jamshedpur urban agglomeration, thereby helping in understanding the spatial settlement pattern. To test the hypothesis, a paired sample t-test was conducted using Jamovi software, comparing urban and slum population data between 2001 and 2011. This test assessed whether the observed changes in the slum population were statistically significant with respect to urban growth. Additionally, a scatterplot was generated to show the correlation between urban and slum population. Thus, this methodology combines statistical techniques, geospatial tools, and literature-based insights to scientifically analyze urbanization patterns and spatial inequalities in the Jamshedpur urban agglomeration.

Hypothesis

"There is variation in slum population along with urbanization in the Jamshedpur urban area."

Study Area

The present research paper focuses on Jamshedpur, an industrial city located in the East Singhbhum district of Jharkhand. The city spans from 86°09′00″ East to 86°16′30″ East longitude and from 20°44′45″ North to 22°50′15″ North latitude. It is situated on the southeastern border of Jharkhand in East Singhbhum district. The average elevation from sea level is 135 meters, and the area covers approximately 150 square kilometers (60 square miles). It is surrounded by the Dalma Hills, Subarnarekha River, Kharkai River, and Dhalbhum hills. The region's two rivers — Subarnarekha and Kharkai , enhance the livability and development of the city. Jamshedpur experiences southern-western monsoon winds bringing rainfall from June to September. It is located on the Chhota Nagpur Plateau. The climate is subtropical and relatively humid. According to the 2011 Census, the total population of Jamshedpur is 1,339,438, out of which 697,926 are male and 641,512 are female.



Source: *District Census Handbook Part-A. Saraikela-Kharsawan and East Singhbhum District*

Figure 1: Location map of Jamshedpur Urban Agglomeration

Results and Discussion

1. Spatio-Temporal Expansion and Growth Trend of Urban Agglomeration in Jamshedpur (1911–2011)

The general meaning of urbanization is the growth of urban areas (Bansal 2020). According to Mitchell: Urbanization is a systematic method through which rural settlements, due to major influences, begin to function as cities. As a result, significant changes occur in the authority of rural institutions, occupations and economy, land use, society and culture, lifestyle and living standards, and other human values.

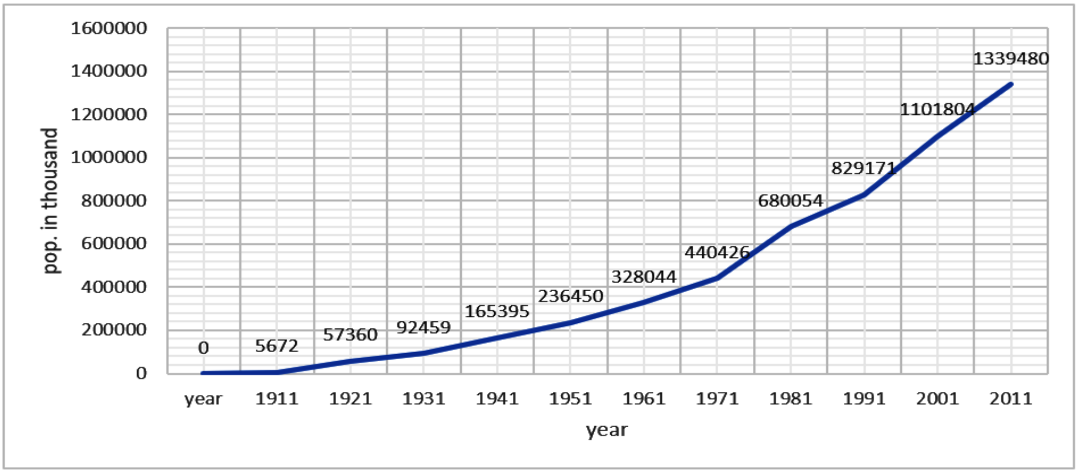
Growth Pattern of Urban Units within Jamshedpur Agglomeration

In Jamshedpur, urbanization occurred as a result of industrialization. After the establishment of Tata Iron and Steel industries, the area developed into a planned city. Along with the industries, other related colonies and settlements were established, leading to city formation. To work in these industrial units, a large population migrated from surrounding rural areas and other states of India and began to settle here. Due to this migration, the urban population of Jamshedpur increased. Urbanization has expanded rapidly due to the centralization of industrial units in and around Jamshedpur. According to Table 1 In 1911, there was only one urban unit with a population of 5,672 . Subsequently, the pace of urbanization accelerated in 1921 and the population increased to 57,360, showing an increase of 911.28%. This increase was due to employment opportunities created by the establishment of industries, which led to large-scale migration from rural areas. Then in 1931, the number of urban units increased to 2 and the population reached 92,459. This showed an increase of 61.19%, which was the result of labour-based migration and the spread of industrial activities. By 1941, the population reached 165,395 and a growth of 78.88% was recorded in this decade. This period can be considered as the phase of industrial consolidation. Subsequently, the pace of urbanization remained relatively stable in the decades 1961, 1971 and 1981, but the number of urban units saw a significant increase. In 1981, the number of urban units rose to 7 and the population exceeded 6.8 lakhs. In 1991, urban units increased to 10, but population growth slowed to 21.93%. In 2001, population rose to 1,101,804, with a slightly higher growth of 32.88%. By 2011, the number of urban units reached 13 and the population reached 1,339,480, but the growth rate declined again to 21.57%.

Table 1: Decadal Variation in Population and Number of Towns in Jamshedpur Urban Agglomeration (1911–2011)

Census year	Number of towns	Urban population	Decadal difference	Percentage of decadal difference
1911	1	5672	-	-
1921	1	57360	+51688	+911.28
1931	2	92459	+35099	+61.19
1941	2	165395	+72936	+78.88
1951	2	236450	+52767	+31.90
1961	2	328044	+109882	+50.37
1971	4	440426	+112382	+34.26
1981	7	680054	+239628	+54.41
1991	10	829171	+149117	+21.93
2001	10	1101804	+272633	+32.88
2011	13	1339480	+237676	+21.57

Source: *Census of India, 1911–2011; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.*

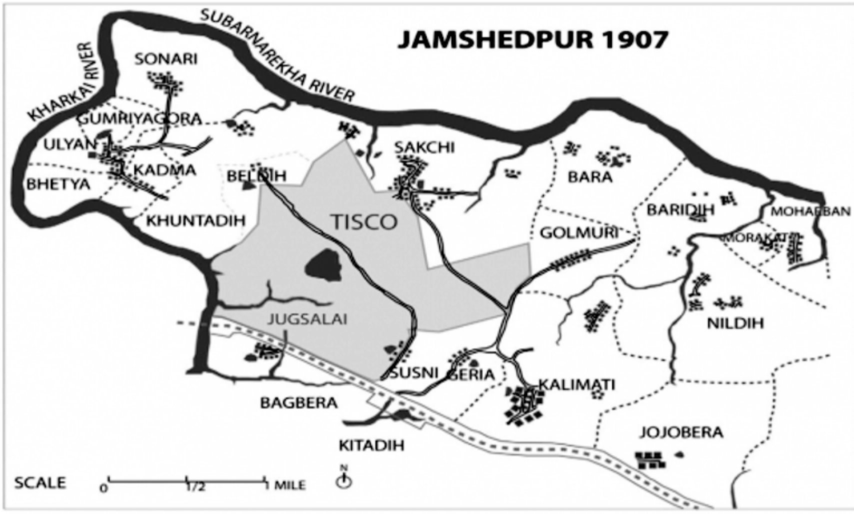


Source: *Based on table 1*

Figure 2: Decadal population growth graph of Jamshedpur urban agglomeration

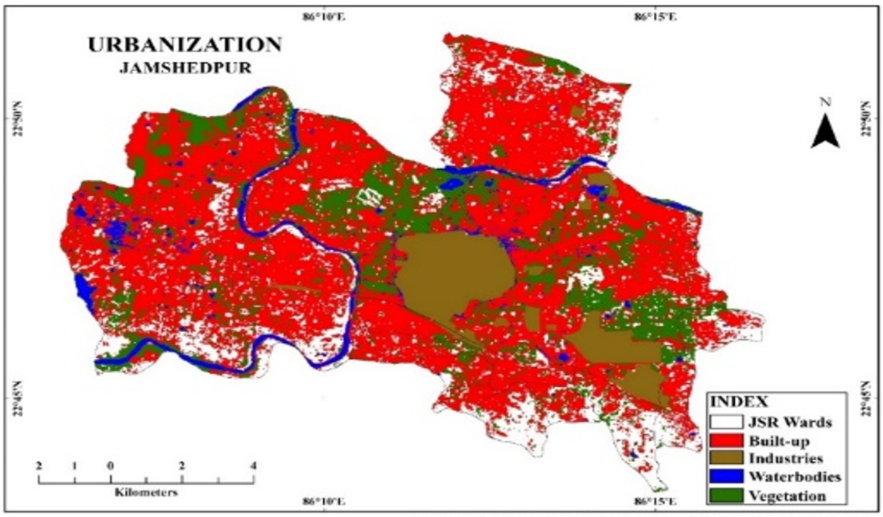
Urban Expansion and Land Use Change due to Industrialization in Jamshedpur

A comparative analysis of Figure 3 and Figure 4 makes it clear that urbanization in Jamshedpur has been driven primarily by the process of industrialization. In Figure 2 (1907), Jamshedpur was a small industrial town with a limited area, mainly TISCO and its associated colonies. On the other hand, Figure 3 (2022) shows that the urban boundary has expanded extensively due to industrial units, road network and other construction work. Satellite imagery shows a massive change in land use—where green areas and agricultural land have decreased and built-up area has increased rapidly.



Source: *TATA STEEL Archive.*

Figure 3 : Urbanization Map of Jamshedpur in 1907 Based on TISCO Planning Records



Source: *Landsat-8, 9 (2022), Processed via USGS Earth Explorer.*

Figure 4 : Urban Land Use and Urbanization Pattern of Jamshedpur, 2022 (Landsat 8–9 Imagery)

Growth Pattern of Urban Units within Jamshedpur Agglomeration

Table 2 shows the number of urban agglomerations, their year of formation, population and area, which shows which urban centres came into existence in which year and what was their area. For example, new urban centres like Adityapur (1971), Mango (1981), Haludbani (1991) and Kandra and Chhota Gamharia (2011) developed, which clearly reflects urban expansion.

Table-2: Growth of cities, urban population and area of Jamshedpur urban agglomeration in different years

	Urban Agglomeration	Year	Population	Area Sq. k.m
1.	Jamshedpur (NC+OG)	1911	5,672	56.32
2.	Jugsalai (M)	1931	8,721	01.29
3.	Bagbera (CT)	1971	28,053	02.24
4.	Adityapur (municipal council)	1971	28,226	49.00
5.	Mango (NAC)	1981	67,284	18.03
6.	Gadhra (CT)	1981	10,744	04.79
7.	Chhota Govindpur (CT)	1981	14,985	02.63
8.	Huludbani (CT)	1991	14,830	03.83
9.	Sarjamda (CT)	1991	10,338	02.53
10.	Ghodabadha (CT)	1991	9,533	03.23
11.	Purihasa (CT)	2011	7897	03.59
12.	Kandra (CT)	2011	8157	01.04
13.	Chhota Gamharia (CT)	2011	7505	00.80

Source: *Census of India, 1911–2011; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.*

Urbanization in Jamshedpur was mainly due to industrialization, migration and planned urban development. But after 2001, the pace of urbanization slowed down somewhat, which points to the ineffectiveness of policy-making, limited land and constraints of structural infrastructure. It is also evident that the number of cities has grown, which has increased the trend of urban sprawl and consequently increased the pressure on urban services.

Slum Growth and Urban Inequality in Jamshedpur Urban Agglomeration (2001–2011)

Urban population often increases more due to urban migration than natural growth (difference between total births and total deaths). Establishment of new cities and transformation of villages into cities also lead to significant increase in urban population. Population in cities has increased at a very fast pace but civic amenities (housing, employment, electricity and water supply, transport, cleanliness, health and other public utility facilities) have not increased in proportion to the population growth, due to which the general standard of living of city dwellers has declined. On one hand, city dwellers are not able to get the required goods and facilities. On the other hand, crowding, dirt, disease, unemployment and many social, economic and environmental problems arise in the city, which hinder in preserving the excellence of urban life and force city dwellers to live a low standard of living. The root cause of urban problems is the excessive concentration of population in cities and unplanned expansion and development of cities. Thus, rapid urbanization creates many types of problems. Industrialization in Jamshedpur has transformed villages into towns and towns into cities along with urbanization. At present, the number of such people is constantly increasing here, who are migrating from villages to towns and from towns to cities in search of employment. They come here and are eager to do any kind of work to earn their livelihood. Their arrival here puts a lot of pressure on civic amenities. The most important problem is that of houses to live in. In fact, there is a lack of houses here according to their level of work. Our cities are not found to be capable of fulfilling their requirement of houses as per their wish. This arrival in cities has forced people to live near roads, railway tracks, and near garbage dumps and flow areas of drains (Bansal, 2020).

Slum Growth and Urban Inequality in Jamshedpur Urban Agglomeration (2001–2011)

Slum is a polluted but densely populated area of the city where houses are not fit for living and the environment is harmful to the health and morals of the citizens (Singh, 2020). Due to the impact of industrialization and population growth, many informal and unorganized settlements have emerged within the urban areas, which have become a major challenge of socio-economic imbalance and urban planning. These slums are built in an unplanned manner along the edge of the planned Jamshedpur city.

Table 3 : Urban and slum population of Jamshedpur urban agglomeration 2001 and 2011

City	2001				2011			
	Urban population	Slum population	Slum population percentage	No. of houses in slum	Urban population	Slum population	Slum population percentage	No. of houses in slum
Jamshedpur (NAC)	612534	66711	10.9	11496	677350	42026	6.20	8829
Mango (NAC)	166155	9000	5.4	3055	223805	30508	13.36	5969
Adityapur (Nagar Parishad)	119233	64785	54.3	14695	174355	29574	16.96	6457
Jugsalai (Nagar Palika)	Data not available	Data not available	Data not available	Data not available	49660	1937	3.90	353
Total	897,922	140,456	15.64	29246	1,125,170	104,045	9.24	21608

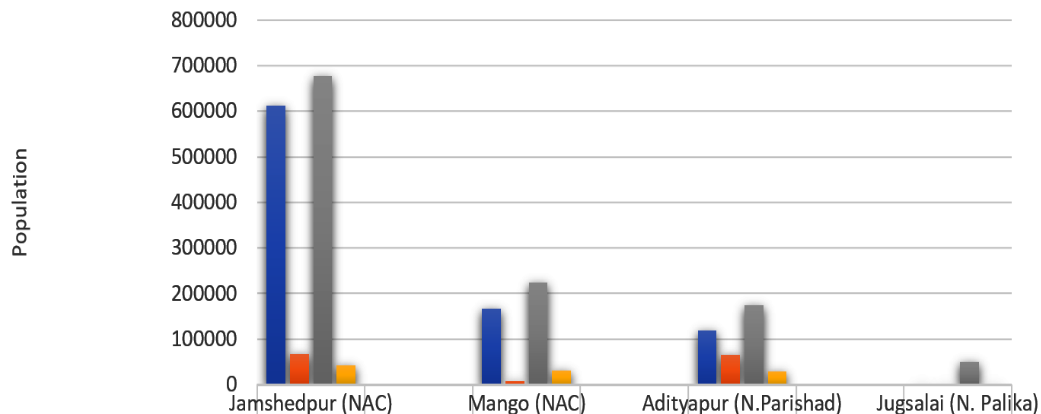
Source: *Census of India 2001 and 2011, Series 21, District Census Handbook, Jharkhand; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India.*

According to Table 3, Comparison of different cities makes it clear that in the year 2001, the percentage of slum population was the highest in Adityapur Municipal Council area at 54.3 percent, which decreased to 16.96 percent in 2011. Jamshedpur NAC had a slum population of 10.9 per cent in 2001, which fell to 6.20 per cent in 2011. Mango NAC, on the other hand, saw an increase in the slum population percentage, from 5.4 per cent in 2001 to 13.36 per cent in 2011. Data for 2001 is not available for the Jugsalai area, but in 2011, it recorded a slum population of only 3.90 per cent.

Between 2001 and 2011, the total number of slum houses in the slum areas of Jamshedpur urban agglomeration witnessed a significant decline. From 29,246 in 2001, the number fell to 21,608 in 2011. This represents a decline of about 26.1%, indicating a structural change in the pattern of slum housing. A spatial analysis of this change reveals that the number of slum houses declined in areas like Adityapur and Jamshedpur NAC, while in contrast, the number of slum houses in Mango NAC increased from 3,055 to 5,969.

This spatial variation indicates that the growth and decline of slum areas has not occurred uniformly, but has depended on factors such as area-specific administrative policies, population migration patterns, and availability of basic amenities. The decline in the number of slums in Adityapur and Jamshedpur NAC can potentially be attributed to the implementation of slum redevelopment schemes, government housing schemes, and the removal of illegal settlements. The activation of urban renewal and planned housing projects in these areas displaced slum structures and converted them into formal housing.

In contrast, the increase in the number of slums in Mango NAC indicates that there has been greater rural-urban migration in this area, leading to an increase in the number of slums. This trend indicates that redevelopment schemes have been relatively weak in this area, and the pressure of migrant population has led to the creation of new unplanned settlements. This growth also poses a challenge for the local administration, as it not only increases housing pressure, but also creates a burden on public services and basic infrastructure.

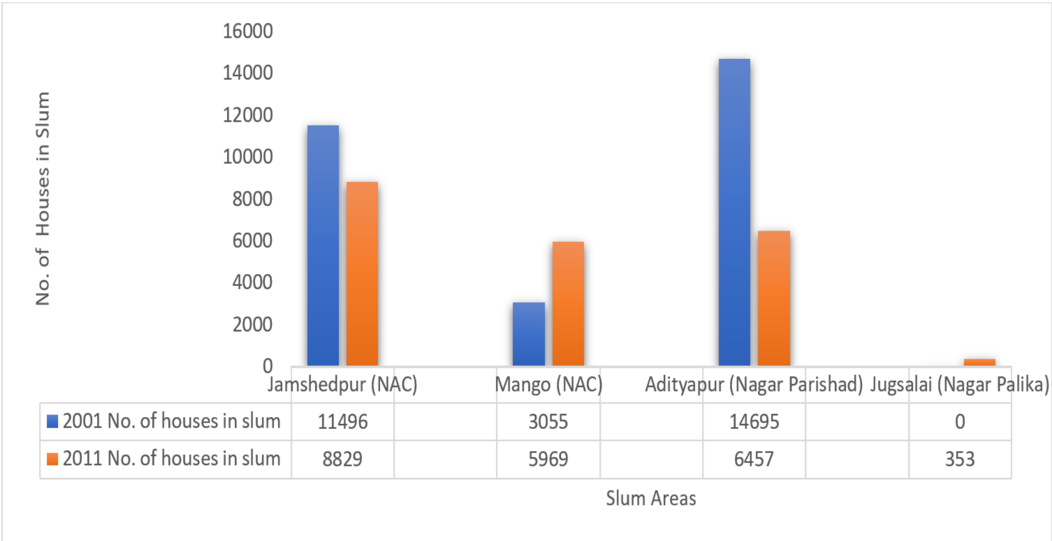


	Jamshedpur (NAC)	Mango (NAC)	Adityapur (N.Parishad)	Jugsalai (N. Palika)
2001 Urban population	612534	166155	119233	0
2001 Slum population	66711	9000	64785	0
2011 Urban population	677350	223805	174355	49660
2011 Slum population	42026	30508	29574	1937

Urban and Slum Areas

Source: *Based on table 3*

Figure-5: Urban and Slum Population of Jamshedpur Urban Agglomeration 2001-2011



Source: Based on table 3

Figure-6: No. of Houses in Slum of Jamshedpur Urban Agglomeration 2001-2011

Trend of Decadal Decline in Slum Population in Jamshedpur Urban Agglomeration (2001–2011)

According to Table-5, between 2001 and 2011, a significant decline in slum population was observed in Jamshedpur urban agglomeration, which is an important indication towards urban development and planning. In the year 2001, the total urban population was 8,97,922, out of which 1,40,456 people lived in slum areas, which was 15.64 percent of the total population. Whereas in 2011, the total population increased to 11,25,170, but the number of slum dwellers decreased to 1,04,045, which was only 9.24 percent. During the same period, the total number of slums also decreased from 29,246 to 21,608.

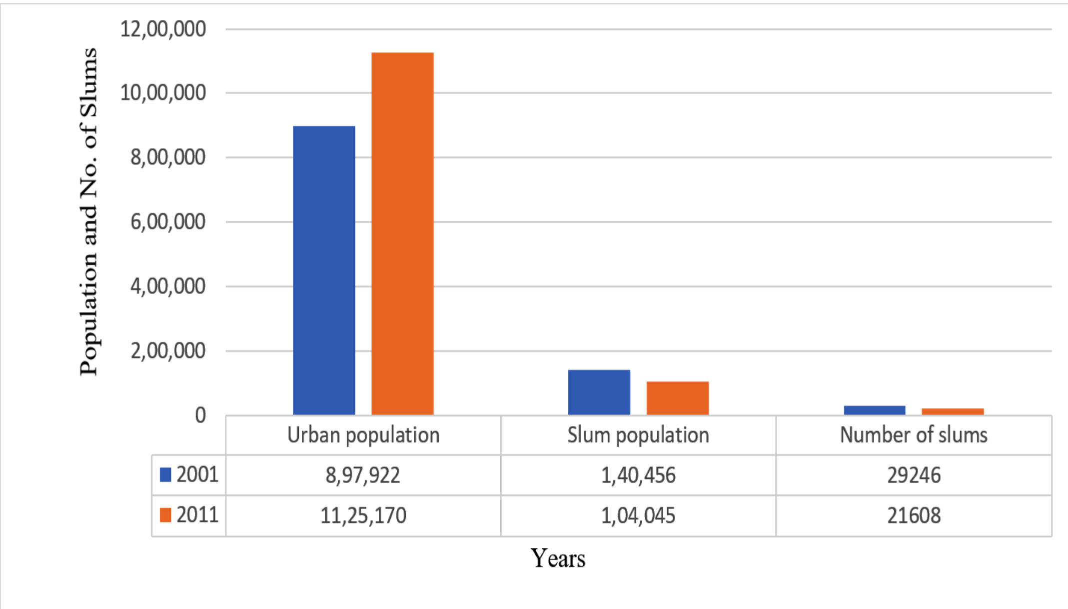
In 2001, Jamshedpur's share in the total slum population of Jharkhand state was 18.43 percent, which decreased to 11.16 percent in 2011. This difference shows that slum redevelopment, housing schemes and availability of basic services have made it possible for both the number and population of slums to decline in Jamshedpur.

While this decline is an indication of the planned development of the city, it also shows that the process of providing alternative housing in place of slum areas or converting them into formal residential areas by the urban administration has been partially successful. Despite this, regional disparities and the need for slum redevelopment in some areas still persist.

Table 4: Decadal Trend of Urban population and slum population of Jamshedpur urban agglomeration from 2001-2011

S.No.	Year	Urban population	Slum population	Number of slums	Percentage of slum population in urban population of Jamshedpur urban agglomeration	Percentage of slum population of Jamshedpur in total slum population of Jharkhand
1.	2001	897922	140456	29246	15.64%	18.43 %
2.	2011	1,125,170	104,045	21608	9.24%	11.16 %

Source: *Census of India 2001 and 2011, Series 21, District Census Handbook, Jharkhand; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India.*



Source : based on table 4

Figure 7: Decadal Trend of Urban Population and No. of Slums of Jamshedpur Urban Agglomeration 2001-2011

Distribution of Slums in Jamshedpur Urban Agglomeration (Based on Census 2011)

according to 2011 Census, shows the geographical location of major slums in the municipal units of Jamshedpur urban agglomeration—namely, Jamshedpur (NAC+OG), Mango (NAC), Adityapur (Municipal Council), and Jugsalai (Municipality). It is evident from Table 5 that the spatial distribution of slums in the urban agglomeration is uneven and depends on their administrative region and socio-economic location.

The Jamshedpur NAC+OG area has the highest number of slums, the major ones being Bage Basti, Birsa Basti, Shyam Nagar, Chhayanagar, Ramnagar, Dimna Basti, Nirmalnagar, Gwala Basti, Kumhar Pada, Bagundatu, Indranagar. This clearly indicates that this area is extremely important not only in terms of population density but also in terms of residence of the working class. The presence of large industrial institutions like Tata Steel in Jamshedpur has attracted a large number of workers here, resulting in the development of slum areas. Mango NAC has slums identified by names like Baganshahi, Garib Nawaz, Baliguma. This area has developed as a suburb of Jamshedpur, where low income group settlements were established due to availability and low price of land. Sapora, Saldih, Parbatipur slums are shown under Adityapur Municipal Council. This area is known as an industrial town, where there is a predominance of small and medium industries, which attracted a large number of working class population and also led to the development of slum areas. Only Garibnawab Colony is listed under Jugsalai Municipality. This slum is spread over a limited area and the number of slums is less.

Table 5 : Slums of Jamshedpur Urban Agglomeration, 2011

	Name of the city	Slum
1.	Jamshedpur (NAC+OG)	Bage Basti , Birsa Basti, Shyam Nagar, Chhayanagar, Ramnagar, Dimna Basti, Nirmalnagar ,Gwala Basti ,Kumhar Pada, Bagundatu, Indranagar.
2.	Mango (NAC)	Baganshahi, Garib Nawaz, Baliguma.
3.	Adityapur (Municipal Council)	Sapra, Saldih, Parbatipur
4.	Jugsalai (Municipality)	Garibanwab Colony

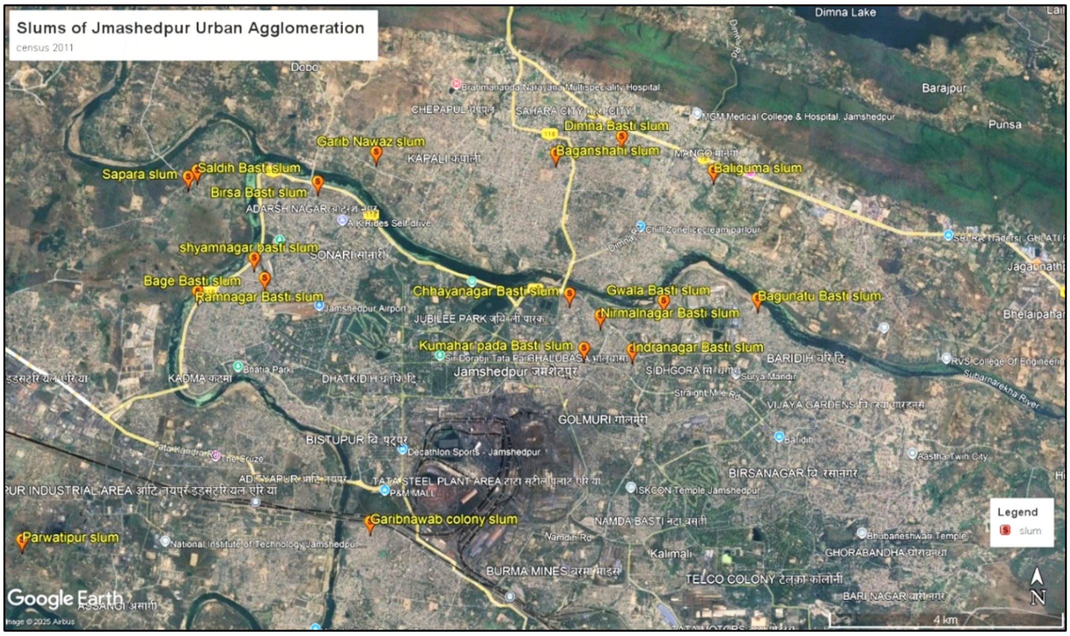
Source: *Census of India 2001 and 2011, Series 21, District Census Handbook, Jharkhand; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India.*

Source: *Images compiled from various e-newspapers, including Sharp Bharat, Dainik Jagran, Masal News, and Uditwani.*

Figure 8: Field Photographs Depicting Housing Conditions in Slum Areas of Jamshedpur Urban Agglomeration

Spatial Distribution of Slums in Jamshedpur Urban Agglomeration Based on Google Earth Pro (2011)

Through the 2011 satellite image of Google Earth Pro, it is evident that slums in the Jamshedpur urban agglomeration are mostly located around industrial areas, railway lines, and rivers. These settlements are spread mainly in the east–west direction and their distribution appears to be unplanned. Settlements like Bagunagar, Kumhartola, Gwala Basti, Parwatipur are concentrated in areas where cheap land is available and working-class settlement is more. This image also indicates that these settlements have developed without a solid urban planning, which has not only led to haphazard urban sprawl but also lack of basic services.



Source: *Google Earth Pro software. Imagery captured on July 18, 2025.*

Figure 9: Spatial Distribution of Slums in Jamshedpur Urban Agglomeration Based on Census 2011 (Mapped via Google Earth Pro)

Slum Redevelopment and Urban Transformation in Jamshedpur Urban Agglomeration

The major reason for slum degradation in Jamshedpur urban area has been the implementation of slum rehabilitation and reconstruction programmes by Jamshedpur Urban Services Limited (JUSCO), municipal bodies and the state government. As Jamshedpur grew industrially and economically, urban planners began to rehabilitate unorganized slums into planned residential complexes. This degradation has been particularly evident in Adityapur and Jamshedpur NAC areas, where many unorganized settlements were cleared and provided with permanent housing.

Construction of 1931 houses under Pradhan Mantri Awas Yojana (Urban) [PMAY-U] has been completed in Jamshedpur urban area. 1304 houses have been completed in Adityapur, 36 houses in Jugsalai, 45 houses in Mango Municipal Corporation area and 546 houses in Jamshedpur Notified Area Committee (JNAC) area. Under the Pradhan Mantri Awas Yojana (Urban), new residential buildings have been constructed in Birsanagar, where slum dwellers are being provided housing as rehabilitation. This project is not an in-situ redevelopment but an attempt at newly established residential sites. Under the 'Affordable Housing Policy' of Jharkhand state, land was identified for 53,000 houses across the state, in which housing subsidy is being given to the EWS category on priority basis. Jamshedpur has also included many areas under this policy, which has accelerated the redevelopment of urban slums. Under the Amrit Yojana for the development of basic urban services (AMRUT), facilities like water supply, sewerage, green areas and transport were expanded. This work was done especially in those slums where the population density was high, but the service delivery system was weak. An attempt was made to improve the quality of urban life through this scheme. The Mohada Water Project provided piped water supply in slum areas like Baridiha, Bagunahatu and Birsanagar. This provided slum dwellers with a clean and permanent water source. Earlier, the health and hygiene conditions in these areas were very poor due to the unavailability of water. Additionally, Jamshedpur Urban Services Limited (JUSCO) also provided basic services like drinking water, toilets, roads and garbage management in some major slum areas, which improved the quality of life and accelerated the process of resettlement from slums.

In addition, administrative decisions like total closure of industrial units, changes in migration patterns and encroachment removal actions in some cases have also affected the slum population. As a result of these changes, many working families either moved back to the rural areas or to other industrial areas.

Source : Google Earth Pro software. Imagery captured on July 18, 2025.

Figure 10: Satellite Image of Pradhan Mantri Awas Yojana Housing Units in Birsanagar, Jamshedpur (Google Earth Pro, 2025)

Hypothesis Test

Statistical study based on Census 2001 and 2011 data shows that on one hand there has been a continuous increase in urban population in Jamshedpur urban agglomeration, on the other hand, there has been a clear decline in the population of slum areas. The total urban population in 2001 was 8,97,922, which increased to 11,25,170 in 2011, which proves that the pace of urbanization has been rapid. On the contrary, the population of slum areas decreased from 1,40,456 to 1,04,045 during the same period, which shows a decrease of about 36,411.

Table 6: Year-wise urban and slum population of Jamshedpur Urban Agglomeration (2001-2011)

S.no.	Year	Urban population	Slum population
1.	2001	897,922	140,456
2.	2011	1,125,170	104,045

Source: *Census of India 2001 and 2011, Series 21, District Census Handbook, Jharkhand; Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India.*

Statistical Validation of Slum Population Variation with Urbanization in Jamshedpur Urban Area (2001–2011)

Hypothesis:

"There is variation in slum population along with urbanization in the Jamshedpur urban area." This hypothesis has been confirmed through both statistical tests and graphical analysis. To prove this hypothesis, a comparative analysis of the urban population and slum population data obtained from the census of 2001 and 2011 was done.

Paired Samples T-Test

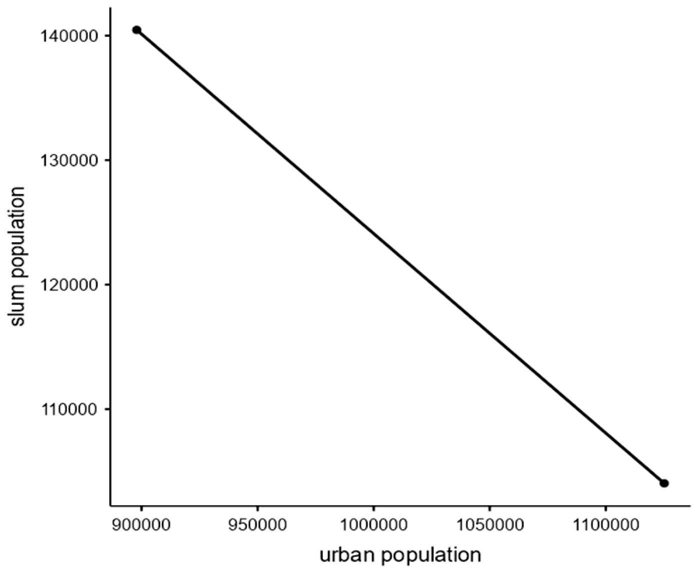
			statistic	df	p
Urban Population	Slum Population	Student's t	6.75	1.00	0.047

Note. H_a $\mu_{\text{Measure 1 - Measure2}} > 0$

Source: *Computed by author based on jamovi software.*

A paired sample t-test was conducted to evaluate the difference in the average urban and slum population between 2001 and 2011. The test yielded a t-value of 6.75 with a p-value of 0.047, which is statistically significant at the 5% level ($p < 0.05$). This result indicates that the observed difference in population means is unlikely to have occurred by chance and reflects a genuine trend in urban and slum population growth. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, supporting the original assumption that there has been a significant change in the slum population relative to urban growth.

Scatterplot



Source: *Computed by author based on jamovi software.*

In addition, this relationship was visually presented using a scatter plot. It shows slum population on the X-axis and urban population on the Y-axis. A negative correlation was found between the data points of 2001 and 2011, indicating that as the urban population increased, the slum population declined. This decline is due to factors such as urban development plans, rehabilitation projects, displacement of illegal settlements, and conversion of slums into formal housing.

Both the statistical test (T-Test) and graphical evidence (Scatterplot) prove that there is a clear change in the slum population with urbanization in Jamshedpur, and the original hypothesis is proved to be completely true.

Conclusion

Based on 2001 and 2011 census data, spatial distribution maps prepared using Google Earth Pro, statistical tests (such as paired sample t-tests) and scatterplot analysis of the Jamshedpur urban agglomeration, it is clear that there have been significant changes in the slum population with urbanization. Although the total urban population has increased, the overall slum population has declined – especially in areas such as Jamshedpur NAC and Adityapur. In contrast, the slum population in the Mango NAC area has increased, reflecting spatial heterogeneity and unevenness of planning. The spatial distribution maps created using Google Earth Pro clearly highlight this uneven growth of slums, showing their concentration near industrial areas and infrastructural corridors and catchment areas of decline where redevelopment initiatives were taken up. The negative correlation depicted by the scatterplot indicates that with the increasing impact of planned urbanization and resettlement programmes, there has been restructuring and displacement of slums. The Pradhan Mantri Awas Yojana, Affordable Housing Policy, Amrit Yojana, Mohada Water Project and basic services provided by JUSCO have resulted in improved living conditions in slums. This study concludes that slum reduction is not a numerical change but an outcome of urban planning and socio-economic transformation.

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URBAN SUSTAINABILITY IN BASTI CITY: LINKING BASIC AMENITIES TO SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

This study assesses the availability and quality of basic amenities across different wards of Basti city, Uttar Pradesh, India, and compares the findings with the targets set by the United Nations Sustainable Development Goals (SDGs). Using secondary data from the 2011 Census of India, the study evaluates the condition of nine critical variables: housing, drinking water, kitchen facilities, lighting, cooking fuel, toilet and bathing facilities, and drainage systems. These indicators provide insights into the disparities in access to essential services in various parts of the city. The results highlight significant gaps in the provision of basic amenities in Basti city. For instance, only 57.50% of households live in well-maintained pucca houses, and a staggering 27.9% of residents still practice open defecation, illustrating severe public health concerns. Drinking water access is another major issue, with 60.90% of the population relying on boreholes, which often do not meet quality standards. Similarly, 18.7% of households use kerosene for lighting, and a mere 61.8% of residents use LPG for cooking. The city also lacks proper drainage infrastructure, with 68.0% of residents living without closed drainage systems, leading to poor sanitation and increased flooding risks. The study compares these conditions with relevant SDG targets, such as ensuring universal access to clean water, sanitation, and affordable energy, as well as promoting sustainable urban development. The findings reveal that Basti city falls short of achieving these global goals, particularly in the areas of water and sanitation, health, and energy access. The lack of adequate amenities reflects broader challenges in urban planning, governance, and socio-economic development in Basti. The study underscores the urgent need for targeted policies and interventions to improve basic services, achieve SDG targets, and enhance the overall quality of life for Basti's residents.

Keywords: *Basic Amenities, Public Health, Sustainable Development Goals (SDGs), Urban Infrastructure.*

Introduction

Urbanization is one of the most transformative phenomena of the 21st century, reshaping settlement patterns, economic growth, and social organization. Cities drive economic development and innovation but also face challenges in ensuring equitable access to basic

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amenities and sustainable resource use. In developing countries like India, rapid urban growth is driven by rural-to-urban migration, high birth rates, and uneven development-places intense pressure on infrastructure. The fast-growing city of Basti in Uttar Pradesh exemplifies this paradox: an emerging socioeconomic hub with infrastructure under severe stress and deeply unequal access to services. Basic amenities like housing, drinking water, sanitation, energy, and waste management are essential for well-being, health, and productivity. Their absence exacerbates inequality, entrenches poverty, and undermines development. Global frameworks like the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) recognize this. While the MDGs (2000) improved health and living conditions, gaps remained in addressing urban poverty and infrastructure (Kabeer, 2010; Nath, 2011). The SDGs (2015) stressed inclusivity and sustainability, with goals such as SDG 6, 7, and 11 directly addressing urban needs. However, translating global targets into local action remains challenging. The MDGs largely overlooked rapid urbanization (Cohen, 2014), and smaller cities struggle with capacity for SDG localization. In Basti, limited clean water access, dependence on boreholes and kerosene, inadequate sanitation, and open defecation persist, highlighting the urgent need for targeted, inclusive strategies to meet global sustainability goals and reduce urban inequality.

The present study seeks to provide a comprehensive assessment of the availability and quality of basic amenities in Basti city, using data from the Census of India (2011) and other secondary sources. By focusing on nine indicators including housing, drinking water, sanitation, drainage, and energy use - the study evaluates disparities in service provision across different wards of the city. Furthermore, it compares these findings against the benchmarks set by the SDGs, highlighting the extent to which Basti aligns with or lags behind global sustainability targets. The analysis not only identifies critical gaps in infrastructure but also underscores the urgent need for policy reforms and urban planning interventions. In doing so, it aims to contribute to broader debates on sustainable urbanization and provide actionable insights for local governance in Basti and similar cities in India.

Literature Review

The relationship between urbanization and human well-being has long been debated in geography, sociology, and development studies. Early works, such as Smith (1977), highlighted the uneven spatial distribution of resources between urban and rural areas. Since the late 1980s, urban poverty has emerged as a key concern, as cities act both as growth engines and sites of stark inequality. Recently, urbanization discourse has increasingly linked sustainability, infrastructure, environmental management, and social justice to global development goals. The Millennium Development Goals (MDGs), adopted in 2000, marked a milestone by addressing poverty, health, education, and environmental sustainability (MDG-UNDP, 2006). However, scholars like Cohen (2014) critique the MDGs for neglecting rapid urban growth challenges in developing countries, while Nath (2011) notes uneven progress and low service uptake among marginalized groups. These critiques highlight the need for global development frameworks to explicitly address urban-specific challenges to ensure inclusive, sustainable urban development. The post-2015 agenda, embodied in the Sustainable Development Goals (SDGs), addresses urban sustainability through 17 goals and 169 targets emphasizing inclusivity, resilience, and environmental sustainability. Key goals related to urban infrastructure include SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 9 (innovation and infrastructure), and SDG 11 (sustainable cities and communities). By linking urban development with broader sustainability objectives, the SDGs offer a comprehensive framework to address urbanization challenges. Chen et al. (2022) note that urbanization can drive economic growth and innovation but also risks environmental degradation and inequality. In India, rapid urbanization driven by population growth, rural-to-urban migration, and economic restructuring presents a complex scenario. While cities fuel national growth, they face major deficits in infrastructure, housing, sanitation, and environmental sustainability (Nathan, 2020). Roy, Garai, and Biswas (2023) analyze 56 Indian cities' SDG performance, revealing uneven progress across goals and regions, with significant inter-city inequalities. These findings stress the need for tailored, context-specific strategies to address urban challenges and achieve SDG targets effectively. Smaller Indian cities like Basti face acute challenges due to limited resources and weak governance, unlike well-resourced metropolitan centers. Tiwari, Chauhan, and Varma (2021) note that SDG localization in small cities is hindered by top-down approaches, limited municipal capacity, and low citizen participation, advocating for bottom-up strategies that empower local governments and communities. Howlader et al. (2019) highlight severe deficits in drinking water, sanitation, and housing, especially in slums, underscoring the need for sustainable governance systems. International studies offer strategies for sustainable urbanization. Bibri, Krogstie, and Kärrholm (2020) promote the compact city model—emphasizing density, diversity, mixed land use, and green spaces to balance economic, social, and environmental goals. Valencia et al. (2019) stress localizing global agendas like the SDGs by considering governance, urban boundaries, and trade-offs. Case studies, such as Markaz Knowledge City in Kerala (Mohammed & Al Kindi, 2022), show how integrated planning in renewable energy, waste management, and economic development can achieve multidimensional urban progress Global and national perspectives highlight challenges faced by cities like Basti. Census 2011 shows over 60.9% of households rely on boreholes for drinking water, open defecation is common, and many depend on kerosene, reflecting persistent energy poverty. Such gaps mirror broader patterns of inequality in access to basic amenities in smaller urban centers. As Chen et al. (2022) note, urbanization can support multiple SDGs, but without proper planning and investment, it risks creating trade-offs that harm environmental sustainability and social justice. Literature emphasizes multi-scalar, interdisciplinary approaches to urban sustainability. Roy et al. (2023) and Nathan (2020) stress integrating environmental concerns into planning, while Tiwari et al. (2021) highlight community participation and localized governance for translating global goals locally. International studies (Bibri et al., 2020; Valencia et al., 2019) reinforce balancing economic, social, and environmental dimensions. These insights offer a strong basis for analyzing Basti's challenges and guiding inclusive, sustainable policy solutions.

In conclusion, while the SDGs offer valuable benchmarks, their success depends on local context, governance, and community engagement. For smaller cities like Basti, assessing basic amenities is crucial to identify gaps. This study situates Basti's challenges within urbanization and sustainability debates to inform targeted, practical solutions for sustainable development.

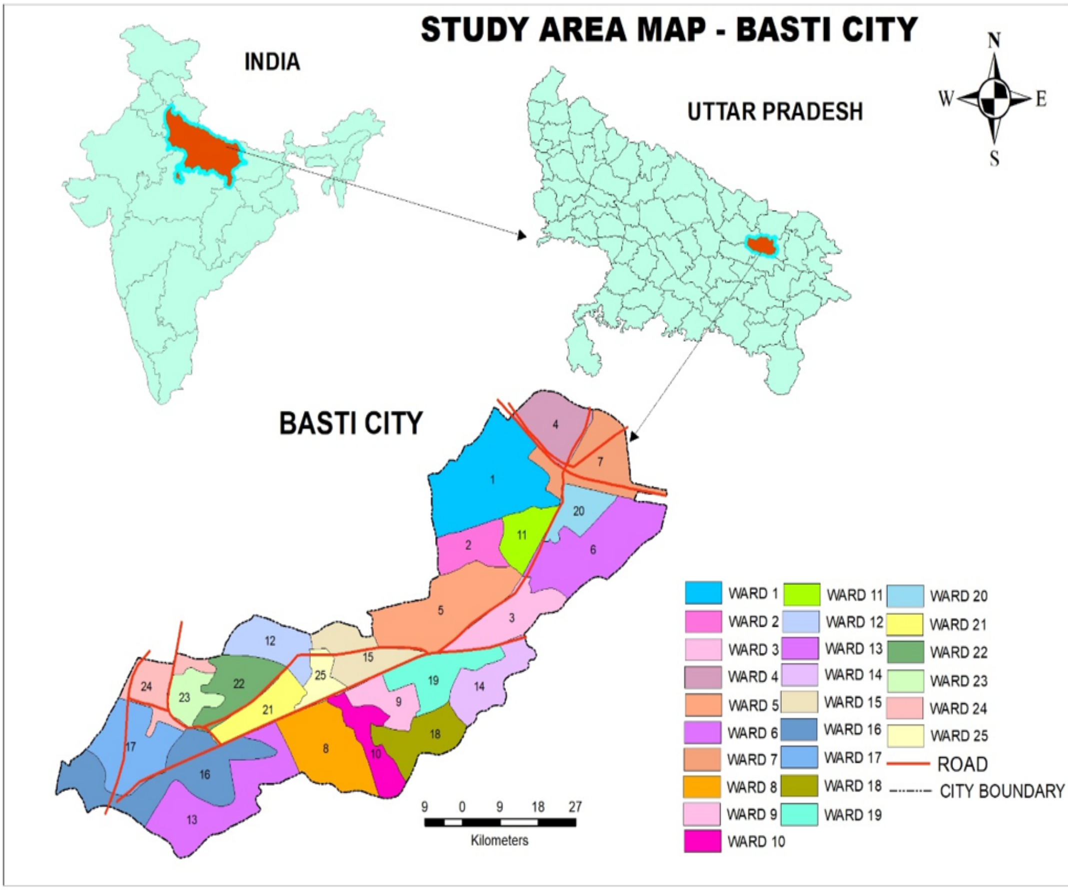
Research Gap

Existing literature on urbanization and basic amenities mainly focuses on large cities, overlooking smaller, fast-growing urban areas like Basti. Research on SDGs often lacks localized analysis, with few studies comparing basic amenity status in such cities to SDG benchmarks. This gap underscores the need for focused research on mid-sized cities to better understand infrastructure disparities, public health challenges, and the effectiveness of urban policies in achieving sustainable development goals.

Study Area

Basti city, the district headquarters of Basti, is located on the banks of the Kuwano River at 26°47′N latitude and 82°43′E longitude, about 80 km northwest of Gorakhpur and 82 km east of Faizabad. Situated in eastern Uttar Pradesh within the Middle Gangetic Plain, it is the district's largest town, with a population of 114,657 (2011) across 25 wards of the Basti Municipal Board. Covering 19.43 km² since 1961, the city has a population density of 5,901 persons/km². Annual rainfall averages 1,044.70 mm, with a mean temperature of 33°C.

Literacy stands at 74%, above the state average of 67.7%, with female literacy at 68% and male literacy at 78%. The sex ratio is 908 females per 1,000 males, slightly below the state average of 912. Governed under the Uttar Pradesh Municipal Act with amendments via the Nagar Palika Act (1994), Basti faces growing urban challenges linked to its rapid population growth and static infrastructure.



Source: *Basti Nagar Palika*

Figure1 : Study Area

Objective

1. To assess the availability and quality of basic amenities across different wards of Basti city.
2. To analyze and compare the condition of basic amenities in Basti city against the targets set by the United Nations Sustainable Development Goals (SDGs).

Methodology

This study adopts a descriptive and analytical research design, drawing upon secondary data sources to examine the availability and quality of basic amenities in Basti city, Uttar Pradesh, and their alignment with the United Nations Sustainable Development Goals (SDGs).

Data Sources

The primary source of data is the *Census of India, 2011 (Town and Village Directory)*, which provides ward-level statistics on housing, water supply, sanitation, energy, and other basic services. Additional information has been compiled from municipal records, published reports, and relevant academic literature to contextualize the findings.

Selection of Indicators

Nine variables were identified as key indicators of basic amenities (X1–X9):

X1. Housing Condition, X2. Main Source of Drinking Water, X3. Location of Drinking Water, X4. Toilet Facilities, X5. Bathing Facilities, X6. Drainage Condition, X7. Kitchen Facility, X8. Source of Lighting, X9. Fuel Used for Cooking

These indicators capture both infrastructural availability and quality dimensions of urban amenities and serve as benchmarks for evaluating Basti city's performance against SDG targets.

Analytical Approach

Ward-level data were compiled and converted into percentages for each indicator. A composite score method was employed, wherein individual indicator values for each ward were aggregated to generate an overall basic amenities index. The mean and standard deviation of the composite scores were calculated to classify wards into three categories: high, medium, and low levels of basic amenities. Comparative analysis was conducted to highlight disparities across wards and to identify structural deficiencies. The findings were systematically compared against relevant SDG targets, particularly SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), and SDG 11 (Sustainable Cities and Communities).

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{N}}$$

Where, σ = Standard Deviation (SD), X=Composite Score, X = Mean Value of Composite Score, N= No. of wards

Scope and Limitations

While the study provides a comprehensive overview of basic amenities in Basti city, its reliance on Census 2011 data restricts the temporal scope of analysis. The absence of recent primary surveys may not capture rapid urban changes over the last decade. Nevertheless, the methodology enables a reliable assessment of structural deficiencies and provides a strong basis for policy recommendations aligned with the SDGs.

Result and Discussion

Indicators of Basic Amenities

In the present study altogether 9 variables have been carefully chosen to determine the existing disparities in basic amenities in different wards of Basti city.

Housing Condition (X1)

Housing conditions, a key basic amenity, include structure, safety, sanitation, and service access, influencing urban development. In Basti city, 57.5% of households live in well-maintained pucca houses, 35.7% in livable homes, and 6.8% in dilapidated conditions, reflecting significant disparities in housing quality and the need for improvement.

Main Source of Drinking Water (X2)

Safe drinking water is a fundamental necessity, as contaminated water causes over half a million deaths annually. It can carry harmful pathogens, toxic chemicals, and radiological hazards, posing serious health risks. While its contribution to mineral intake is uncertain, ensuring safe water is a global priority. In Basti city, 38.3% of residents use municipal taps, 60.9% depend on boreholes, and 0.8% rely on other sources, highlighting significant reliance on potentially unsafe water sources and the need for improved water safety measures.

Location of Drinking Water (X3)

Access to drinking water is vital for health, economy, and quality of life. Its availability and proximity greatly affect urban well-being. In the study, 80.8% of residents access water within their premises, 16.1% from nearby sources, and 3.1% from more distant locations, highlighting variations in accessibility.

Toilet Facilities (X4)

Toilet facilities are vital for public health, sanitation, and dignity. They reflect broader social and economic conditions in urban areas. In Basti city, 72.1% of residents have private toilets, but 27.9% still practice open defecation, posing serious health risks and underscoring the urgent need for improved sanitation infrastructure.

Bathing Facilities (X5)

Bathing facilities are vital for hygiene, health, and quality of life. In Basti city, 76.3% of residents have access to such facilities, while 23.7% lack them. This shortfall reflects inadequate infrastructure, poor urban planning, socio-economic disparities, and limited local government support in ensuring essential amenities for all residents.

Drainage Condition (X6)

Effective wastewater management is crucial for sanitation and health. In Basti city, only 32% has closed drainage, while 68% lack proper systems. Blocked or absent sewerage and clogged open drains cause poor sanitation, flooding, and health risks. Urgent upgrades in drainage and sewerage infrastructure are needed to improve living conditions.

Kitchen Facility (X7)

Kitchen facilities are a crucial component of basic amenities, enabling food preparation and cooking. Access to well-equipped kitchens promotes nutrition, health, and hygiene, contributing to the overall quality of life. It has witnessed that only 63.6% household has separate kitchen while majority of household (36.4%) does not have kitchen.

Source of Lighting (X8)

Lighting is a vital aspect of basic amenities, ensuring safety and security at home. Adequate lighting enhances visibility, supports daily activities, and improves overall living conditions, contributing to well-being. It has been reported that majority of households in the city used kerosene (18.7%) as a source of lighting, while, 81 per cent household used electricity as a source of lighting. But it is notable that majority of household had no legal connection.

Fuel Used for Cooking (X9)

The type of fuel used for cooking is a key parameter of basic amenities. Access to clean, safe cooking fuel improves health outcomes, reduces indoor air pollution, and enhances overall quality of life in households. It is notable that only 61.8 per cent city dwellers used LPG for cooking purpose. Though much of them have not got LPG connection, they use the small cylinders of 2 kg and 4 kg. Kerosene, coal and cow-dug-cakes are major fuels for cooking.

Table 1: Selected Variables for Level of Basic Amenities of Different Wards of Basti City

Parameter			Housing Condition			Main Source of Drinking Water			Location of Drinking Water			Toilet Facilities		Bathing Facilities		Drainage Condition		Kitchen Facilities		Main Source of Lighting			Fuel Used for Cooking		
Indicator			Good	Livable	Dilapidated	Municipal Tape	Well Tube well Borehole	Other Sources	Within Premises	Near Premises	Away	Own Toilet	Open Defecation	Yes	No	Closed Drainage	NO Drainage	Has Kitchen	Does not have kitchen	Electricity/ Solar Energy	Kerosene	No lighting	LPG/Biogas/Electricity	Coal/Charcoal/ Kerosene	Wood/Cowdung cake/crop residue
Ward No.	Ward Name	Weightage	1	2	3	1	2	3	1	2	3	1	2	1	2	1	2	1	2	1	2	3	1	2	3
1	Narhariya	% of HH	0.39	0.47	0.14	0.37	0.63	0	0.57	0.35	0.09	0.28	0.72	0.42	0.58	0.06	0.95	0.32	0.68	0.46	0.54	0.0000	0.19	0.07	0.73
		X Value	0.39	0.94	0.43	0.37	1.26	0.01	0.57	0.7	0.26	0.28	1.43	0.42	1.16	0.06	1.89	0.32	1.4	0.46	1.08	0.0030	0.19	0.15	2.20
2	Mishraulia	% of HH	0.41	0.47	0.11	0.5	0.5	0	0.61	0.35	0.04	0.44	0.57	0.64	0.36	0.13	0.88	0.38	0.62	0.59	0.40	0.0002	0.36	0.03	0.60
		X Value	0.41	0.95	0.34	0.5	1	0.01	0.61	0.71	0.11	0.44	1.13	0.64	0.72	0.13	1.75	0.38	1.2	0.59	0.80	0.0180	0.36	0.06	1.80
3	Mulraliot	% of HH	0.7	0.28	0.02	0.69	0.31	0	0.84	0.13	0.03	0.85	0.16	0.93	0.07	0.25	0.75	0.82	0.18	0.88	0.13	0.0000	0.79	0.01	0.20
		X Value	0.7	0.57	0.05	0.69	0.62	0	0.84	0.26	0.1	0.85	0.31	0.93	0.14	0.25	1.49	0.82	0.4	0.88	0.25	0.0000	0.79	0.02	0.60
4	Pandey Bazar	% of HH	0.79	0.17	0.04	0.51	0.48	0.01	0.82	0.15	0.03	0.73	0.27	0.77	0.23	0.39	0.61	0.62	0.38	0.85	0.14	0.0002	0.61	0.05	0.34
		X Value	0.79	0.35	0.11	0.51	0.96	0.03	0.82	0.3	0.1	0.73	0.53	0.77	0.46	0.39	1.21	0.62	0.8	0.85	0.29	0.0180	0.61	0.11	1.01
5	Picaura Shivgula	% of HH	0.46	0.4	0.15	0.26	0.74	0	0.68	0.28	0.04	0.69	0.31	0.75	0.25	0.54	0.46	0.51	0.48	0.81	0.18	0.0001	0.59	0.08	0.33
		X Value	0.46	0.79	0.44	0.26	1.48	0	0.68	0.55	0.13	0.69	0.63	0.75	0.49	0.54	0.91	0.51	1.0	0.81	0.37	0.0120	0.59	0.15	0.98
6	Chikwa tola	% of HH	0.56	0.36	0.08	0.1	0.9	0	0.92	0.06	0.02	0.84	0.16	0.84	0.16	0.27	0.73	0.72	0.28	0.91	0.08	0.0001	0.73	0.06	0.20
		X Value	0.56	0.71	0.25	0.1	1.8	0.01	0.92	0.13	0.05	0.84	0.33	0.84	0.32	0.27	1.46	0.72	0.6	0.91	0.17	0.0120	0.73	0.12	0.59

7	Surti Hatta	% of HH	0.65	0.27	0.08	0.53	0.47	0	0.88	0.1	0.02	0.78	0.22	0.8	0.2	0.55	0.45	0.61	0.38	0.88	0.12	0.0001	0.58	0.05	0.35
		X Value	0.65	0.54	0.23	0.53	0.93	0.01	0.88	0.19	0.07	0.78	0.45	0.8	0.41	0.55	0.9	0.61	0.8	0.88	0.23	0.0060	0.58	0.10	1.04
8	Turkahiya	% of HH	0.4	0.45	0.15	0.2	0.79	0.02	0.76	0.2	0.04	0.68	0.33	0.74	0.26	0.48	0.52	0.47	0.52	0.86	0.14	0.0000	0.63	0.11	0.25
		X Value	0.4	0.89	0.46	0.2	1.58	0.05	0.76	0.4	0.11	0.68	0.65	0.74	0.53	0.48	1.05	0.47	1.0	0.86	0.29	0.0000	0.63	0.22	0.74
9	Visunpur wa	% of HH	0.68	0.3	0.03	0.23	0.77	0.01	0.94	0.06	0	0.93	0.07	0.88	0.12	0.16	0.85	0.82	0.18	0.97	0.03	0.0000	0.84	0.05	0.11
		X Value	0.68	0.59	0.08	0.23	1.54	0.02	0.94	0.11	0.01	0.93	0.13	0.88	0.24	0.16	1.69	0.82	0.4	0.97	0.06	0.00	0.84	0.10	0.33
10	Mali Tola	% of HH	0.38	0.51	0.11	0.26	0.71	0.03	0.79	0.18	0.03	0.59	0.41	0.5	0.5	0.24	0.76	0.32	0.67	0.80	0.18	0.0007	0.46	0.07	0.47
		X Value	0.38	1.02	0.33	0.26	1.42	0.09	0.79	0.35	0.1	0.59	0.83	0.5	1	0.24	1.52	0.32	1.3	0.80	0.35	0.0690	0.46	0.15	1.41
11	Pathan Tola	% of HH	0.74	0.21	0.05	0.62	0.36	0.01	0.91	0.07	0.02	0.93	0.07	0.9	0.11	0.4	0.6	0.82	0.18	0.93	0.07	0.0000	0.83	0.04	0.13
		X Value	0.74	0.41	0.15	0.62	0.72	0.04	0.91	0.15	0.05	0.93	0.14	0.9	0.21	0.4	1.2	0.82	0.4	0.93	0.14	0.0030	0.83	0.08	0.39
12	Rautap ar	% of HH	0.24	0.65	0.11	0.52	0.47	0.01	0.77	0.19	0.05	0.73	0.27	0.83	0.17	0.51	0.49	0.56	0.44	0.84	0.15	0.0002	0.47	0.11	0.42
		X Value	0.24	1.3	0.33	0.52	0.93	0.03	0.77	0.38	0.14	0.73	0.54	0.83	0.34	0.51	0.98	0.56	0.9	0.84	0.31	0.0180	0.47	0.22	1.25
13	Mahrik hwa	% of HH	0.51	0.41	0.09	0.22	0.77	0.01	0.86	0.09	0.05	0.69	0.31	0.71	0.29	0.08	0.92	0.36	0.63	0.80	0.19	0.0150	0.55	0.10	0.34
		X Value	0.51	0.81	0.26	0.22	1.53	0.04	0.86	0.18	0.16	0.69	0.62	0.71	0.58	0.08	1.84	0.36	1.3	0.80	0.39	0.0002	0.55	0.19	1.03
14	Gaong adiya	% of HH	0.58	0.37	0.05	0.71	0.29	0	0.84	0.14	0.02	0.86	0.14	0.88	0.12	0.44	0.57	0.72	0.27	0.90	0.11	0.0000	0.80	0.02	0.18
		X Value	0.58	0.74	0.16	0.71	0.58	0.01	0.84	0.29	0.06	0.86	0.29	0.88	0.25	0.44	1.13	0.72	0.5	0.90	0.21	0.0000	0.80	0.03	0.53
15	Pisaura Daturai	% of HH	0.61	0.35	0.05	0.69	0.3	0.01	0.89	0.11	0.01	0.84	0.16	0.83	0.17	0.26	0.74	0.82	0.18	0.92	0.08	0.0000	0.76	0.02	0.21
		X Value	0.61	0.69	0.14	0.69	0.59	0.03	0.89	0.22	0.02	0.84	0.32	0.83	0.33	0.26	1.47	0.82	0.4	0.92	0.17	0.0000	0.76	0.03	0.64
16	Compa ny	% of HH	0.73	0.23	0.04	0.29	0.69	0.02	0.91	0.07	0.02	0.94	0.06	0.88	0.12	0.41	0.59	0.83	0.17	0.95	0.05	0.0000	0.85	0.03	0.12
		X Value	0.73	0.47	0.11	0.29	1.38	0.05	0.91	0.14	0.05	0.94	0.12	0.88	0.25	0.41	1.17	0.83	0.3	0.95	0.10	0.0000	0.85	0.06	0.35
17	Purana Dakkha	% of HH	0.76	0.21	0.02	0.22	0.78	0	0.91	0.08	0	0.92	0.08	0.96	0.04	0.76	0.24	0.83	0.17	0.98	0.02	0.0000	0.85	0.08	0.07
		X Value	0.76	0.43	0.07	0.22	1.56	0	0.91	0.17	0.01	0.92	0.17	0.96	0.08	0.76	0.48	0.83	0.3	0.98	0.04	0.0000	0.85	0.16	0.20
18	Belwadadi	% of HH	0.33	0.59	0.08	0.18	0.81	0.01	0.74	0.25	0.02	0.43	0.57	0.66	0.34	0.24	0.76	0.56	0.43	0.48	0.52	0.0002	0.28	0.03	0.26
		X Value	0.33	1.17	0.25	0.18	1.62	0.02	0.74	0.5	0.05	0.43	1.15	0.66	0.68	0.24	1.52	0.56	0.9	0.48	1.03	0.0180	0.28	0.06	0.77
19	Oriiot	% of HH	0.53	0.4	0.07	0.35	0.63	0.02	0.89	0.09	0.02	0.81	0.19	0.75	0.25	0.24	0.76	0.58	0.42	0.84	0.16	0.0000	0.67	0.04	0.28
		X Value	0.53	0.79	0.22	0.35	1.26	0.06	0.89	0.18	0.07	0.81	0.38	0.75	0.49	0.24	1.51	0.58	0.8	0.84	0.32	0.0030	0.67	0.09	0.84

20	Italia	% of HH	0.59	0.38	0.03	0.21	0.78	0.02	0.94	0.06	0.01	0.95	0.05	0.9	0.1	0.44	0.56	0.72	0.27	0.96	0.03	0.0001	0.86	0.06	0.07
		X Value	0.59	0.76	0.09	0.21	1.55	0.05	0.94	0.11	0.02	0.95	0.11	0.9	0.2	0.44	1.12	0.72	0.5	0.96	0.07	0.0090	0.86	0.12	0.21
21	Rames hwarpu	% of HH	0.71	0.22	0.06	0.18	0.81	0.01	0.9	0.08	0.02	0.94	0.07	0.83	0.17	0.43	0.58	0.73	0.27	0.93	0.07	0.0000	0.77	0.09	0.14
		X Value	0.71	0.45	0.19	0.18	1.62	0.02	0.9	0.16	0.05	0.94	0.13	0.83	0.33	0.43	1.15	0.73	0.5	0.93	0.13	0.0000	0.77	0.18	0.43
22	Bairiha wa	% of HH	0.77	0.22	0.01	0.63	0.36	0	0.98	0.02	0	1	0	0.94	0.06	0.19	0.81	0.92	0.08	0.99	0.01	0.0000	0.94	0.03	0.03
		X Value	0.77	0.44	0.03	0.63	0.73	0.01	0.98	0.05	0	1	0.01	0.94	0.13	0.19	1.62	0.92	0.2	0.99	0.02	0.0000	0.94	0.06	0.09
23	Awas Vikas	% of HH	0.61	0.38	0.01	0.22	0.78	0	0.9	0.09	0.01	0.84	0.16	0.86	0.14	0.34	0.66	0.84	0.16	0.96	0.04	0.0001	0.68	0.02	0.30
		X Value	0.61	0.75	0.04	0.22	1.56	0.01	0.9	0.17	0.03	0.84	0.33	0.86	0.28	0.34	1.31	0.84	0.3	0.96	0.08	0.0120	0.68	0.04	0.89
24	Katra	% of HH	0.61	0.36	0.04	0.66	0.34	0	0.91	0.08	0.01	0.87	0.13	0.91	0.09	0.38	0.62	0.79	0.21	0.97	0.03	0.0001	0.80	0.05	0.15
		X Value	0.61	0.71	0.11	0.66	0.68	0	0.91	0.16	0.02	0.87	0.25	0.91	0.17	0.38	1.25	0.79	0.4	0.97	0.06	0.0060	0.80	0.09	0.46
25	Pikaura Buksh	% of HH	0.49	0.45	0.07	0.15	0.85	0.01	0.83	0.16	0.01	0.93	0.07	0.97	0.03	0.39	0.61	0.95	0.05	0.96	0.04	0.0001	0.89	0.08	0.03
		X Value	0.49	0.9	0.2	0.15	1.69	0.03	0.83	0.33	0.04	0.93	0.14	0.97	0.05	0.39	1.21	0.95	0.1	0.96	0.08	0.0060	0.89	0.15	0.10

Source: *Computed by author, Census of India, 2011*

Spatial Disparities of Basic Amenities

To determine the spatial disparities of basic amenities, quantitative and qualitative analysis of data has been done. Aggregates of the entire variable have been taken. A composite score has been calculated by adding up all the variables for different wards separately. (Table 2)

Table 2: Composite score for basic amenities of Basti city

Ward	X1	X2	X3	X4	X5	X6	X7	X8	X9	Composite X	$X-\bar{X}$	$(X-\bar{X})^2$
Narhariya	1.76	1.64	1.52	1.72	1.58	1.95	1.67	1.54	2.53	15.91	3.51	12.29
Mishraulia	1.7	1.5	1.43	1.57	1.36	1.88	1.62	1.41	2.23	14.70	2.30	5.28
Murlijot	1.32	1.31	1.2	1.16	1.07	1.75	1.18	1.13	1.41	11.53	-0.88	0.77
Pandey Bazar	1.24	1.5	1.22	1.27	1.23	1.61	1.38	1.16	1.72	12.33	-0.07	0.01
Picaura Shivgulam	1.69	1.74	1.36	1.31	1.25	1.46	1.48	1.19	1.73	13.21	0.81	0.65
Chikwa tola	1.52	1.91	1.1	1.16	1.16	1.73	1.28	1.09	1.45	12.40	0.00	0.00
Surti Hatta	1.42	1.47	1.14	1.22	1.2	1.45	1.37	1.12	1.73	12.12	-0.28	0.08

Turkahiya	1.75	1.82	1.28	1.33	1.26	1.52	1.51	1.14	1.59	13.20	0.80	0.65
Visunpurwa	1.35	1.78	1.06	1.07	1.12	1.85	1.18	1.03	1.27	11.71	-0.69	0.47
Mali Tola	1.73	1.77	1.24	1.41	1.5	1.76	1.67	1.22	2.01	14.31	1.91	3.66
Pathan Tola	1.31	1.38	1.11	1.07	1.11	1.6	1.18	1.07	1.30	11.13	-1.27	1.61
Rautapar	1.87	1.48	1.28	1.27	1.17	1.49	1.43	1.16	1.94	13.09	0.69	0.48
Mahrikhawa	1.58	1.8	1.2	1.31	1.29	1.92	1.63	1.19	1.78	13.70	1.30	1.68
Gaongadiya	1.47	1.29	1.18	1.14	1.12	1.57	1.26	1.11	1.36	11.50	-0.90	0.81
Picaura Daturai	1.44	1.32	1.12	1.16	1.17	1.74	1.17	1.08	1.44	11.64	-0.76	0.57
Company Bagh	1.3	1.72	1.11	1.06	1.12	1.59	1.17	1.05	1.26	11.38	-1.03	1.05
Purana Dakkhana	1.26	1.78	1.09	1.08	1.04	1.24	1.16	1.02	1.21	10.88	-1.52	2.30
Belwadadi	1.76	1.82	1.28	1.57	1.34	1.76	1.43	1.53	1.11	13.59	1.19	1.42
Orijot	1.54	1.67	1.14	1.19	1.25	1.76	1.41	1.16	1.59	12.72	0.32	0.10
Itailia	1.44	1.8	1.07	1.05	1.1	1.56	1.26	1.04	1.19	11.50	-0.90	0.80
Rameshwarpuri	1.35	1.83	1.11	1.07	1.17	1.58	1.27	1.07	1.37	11.82	-0.58	0.33
Bairihawa	1.24	1.37	1.02	1	1.06	1.81	1.08	1.01	1.09	10.68	-1.72	2.94
Awas Vikas	1.4	1.78	1.11	1.16	1.14	1.66	1.16	1.05	1.61	12.07	-0.33	0.11
Katra	1.43	1.34	1.09	1.13	1.09	1.62	1.20	1.03	1.35	11.28	-1.12	1.25
Pikaura Buksh	1.58	1.87	1.19	1.07	1.03	1.61	1.05	1.05	1.14	11.59	-0.81	0.66
Total										**309.98**		**39.97**

Source: Computed by Author, 2024

X = 12.40, σ= 2.55

There after mean value of composite score is derived. Composite score of **25 wards** come to **309.98** and the mean value is **12.40.** Deviation from the mean value for each ward has been taken. The square value gives a total of 39.97. Thereafter SD is calculated and it comes to 2.55. The levels of basic amenities under deviation are grouped in the Table 3.

Table 3: Level of basic amenities in Basti city

Level of Basic Amenities	Statistical Value	Composite Score	Name of Wards
Area With High Basic Amenities	**+σ to +2σ**	14.95 to 17.50	Narhariya
Area With Medium Basic Amenities	**to +σ**	12.40 to 14.95	Mishraulia, Mali Tola, Mahrikhawa, Belwadadi, Picaura-Shivgulam, Turkahiya, Rautapar, Orijot
Area With Poor Basic Amenities	**− σ to**	9.85 to 12.40	Murlijot, Pandey Bazar, Surti Hatta, Vishun Purwa, Gaongadiya, Picaura Datturai, Company Bagh, Italia, Rameshwarpuri, Awas Vikas, Pikaura Buksh, Chikwa Tola, Pathan Tola, Purana Dakkhana, Bairihawa

Source: *Computed by Author, 2024*

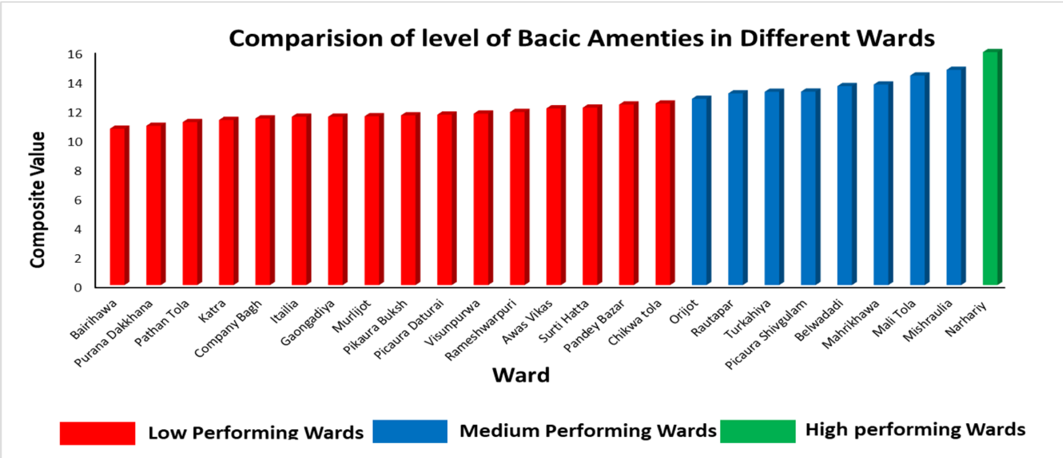


Figure 2 : Comparision of level of Basic Amenties in Different Wards

Comparison of Level of Basic Amenities in Different Wards

Figure 2 shows ward performance in basic amenities using a composite value scale, grouped as low-performing (red), medium-performing (blue), and high-performing (green), ranging from 11 to 16 (Fig. 3). Most wards (17) fall in the low-performing category, including Bairihawa, Purana Dakkhana, Pathan Tola, Katra, Company Bagh, Italia, Gaongadiya, Murijot, Pikaura Buksh, Pikaura Datturai, Vishunpurwa, Rameshwarpuri, Awas Vikas, Surti Hatta, Pandey Bazar, Chikwa Tola, and Orijot. With composite values between 11 and 12.5, they lack safe water, sanitation, housing, electricity, and waste management. Being old, congested areas, infrastructural expansion remains highly constrained.Seven medium-performing wards (Rautapar, Turkahiya, Pikaura-Shivgulam, Belwadadi, Maharikhawa, Mali Tola, and Mishraulia) score between 12.7 and 15. As emerging business hubs with new colonies and infrastructure, they show moderate progress but lack a proper master plan, resulting in partial development and uneven urban growth. Narhariya ward, with a composite value above 16, stands out as the only high-performing ward. Once part of a princely estate, it benefited from planned development, resulting in advanced basic amenities and serving as a benchmark for effective governance and resource allocation. In contrast, most wards remain underdeveloped, with only a few showing moderate progress. This stark disparity highlights socio-economic inequality across the city and stresses the urgent need for equitable and inclusive development strategies.

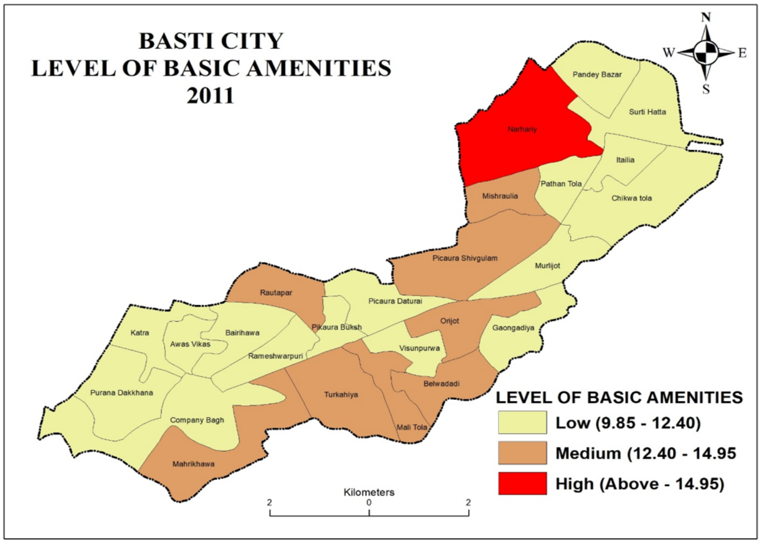


Figure 3 : Basti City Level of Basic Amenities 2011

UN Sustainable Development Goals and Availability of Basic Amenities in Basti City

This section examines SDG goals and targets in relation to basic services in Basti city (Table 4). It highlights inadequate amenities across wards and gaps in policies and programs. Linked to the UN Millennium Declaration, the analysis emphasizes challenges in education, health, poverty reduction, and environmental sustainability (Kabeer, 2010). The UN-SDGs emphasize public health, clean water, energy access, and sustainable cities, setting ambitious goals to be achieved by 2030. In public health, the goals include ensuring healthy lives, increasing life expectancy, reducing maternal and child mortality, and combating major diseases like HIV/AIDS, tuberculosis, and malaria. Targets include reducing maternal mortality to below 70 per 100,000 live births, under-5 mortality to 25 per 1,000, and newborn deaths to 12 per 1,000, while ending epidemics and reducing pollution-related illnesses. In Basti city, the situation remains alarming. Over 60.9% of households depend on hand pumps for drinking water, which do not meet quality standards, while 19.2% must fetch water from outside their premises. Sanitation is equally poor: 27.9% of residents practice open defecation, 68% households face inadequate sewerage, and 23.7% lack bathing facilities. These shortfalls highlight severe challenges in achieving the SDG goal of universal access to safe water, sanitation, and hygiene. Affordable and clean energy is another priority of the SDGs, with targets such as ensuring universal access to modern energy services, expanding renewable energy, and improving energy efficiency. Yet in Basti, about 18.7% of households still rely on kerosene for lighting, and only 61.8% have LPG connections. Many residents use small cylinders instead of full domestic connections, reflecting limited access to sustainable energy. For sustainable cities and communities, SDGs aim to ensure safe housing, create job opportunities, improve slums, promote sustainable urbanization, reduce environmental impacts, and expand green public spaces. However, in Basti, around 42.5% of houses are in livable or poor condition, and only 63.6% of households have a separate kitchen. These conditions underscore critical gaps in infrastructure, planning, and resource allocation, demanding urgent interventions for inclusive urban development aligned with SDG targets.

The comparative study of dwellers in Basti city with respect to the UN-SDGs portrays a picture of severe deficiencies. In order to achieve these goals, it is essential to understand the consequences of the problems faced by this city.

Table 4: UN-SDGs, and Status of Wards of Basti City

	UN- SDGs	Status of Wards
SDGs Goal 3: GOOD HEALTH AND WELL-BEING	**Goals:** • Ensure healthy lives and promote well-being • Increasing life expectancy • Reduce child and maternal mortality • Reduce malaria, tuberculosis, polio and the spread of HIV/AIDS. **Targets:** • Reduce the number of deaths and illnesses from pollution-related diseases. • By 2030, reduce the global maternal mortality rate to less than 70 per 100,000 live births. • By 2030, reduce preventable deaths of new born at least as low as 12 per 1,000 live births. • By 2030, reduce child mortality (under-5 age) at least as low as 25 per 1,000 live births. • By 2030, end the epidemics of AIDS, tuberculosis, malaria, hepatitis, water -borne diseases and other communicable diseases. • By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.	• Approximately 6 0.90% of households in various wards of the city rely on hand pumps (boreholes) for drinking water, which do not meet quality standards. • About 19.2% household collect drinking water from either nearby or away from their premises.

SDGs Goal 6: CLEAN WATER AND SANITATION	**Goals** • Ensure availability and sustainable management of water and sanitation for all **Targets:** • By 2030, achieve universal and equitable access to safe and affordable drinking water for all • By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. • By 2030, improve water qu ality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	• Over 27.9% of the population practices open defecation. • About 6 0.90% of households in various wards of the city rely on hand pumps (boreholes) for drinking water, which do not meet quality standards. • About 19.2% household collect drinking water from either nearby or away from their premises. • About 68.0% households have very poor condition sewerage facilities. • Approximately 23.7% of residents in the city do not have access to bathing facilities.
SDGs Goal 7: AFFORDABLE AND CLEAN ENERGY	**Goals:** • Improving energy productivity, and ensuring energy for all • Expanding infrastructure and upgrading technology to provide clean and more efficient energy in all **Target:** • By 2030, ensure universal access to affordable, reliable and modern energy services • By 2030, increase substantially the share of renewable energy in the global energy mix • By 2030, double the global rate of improvement in energy efficiency • By 2030, enhance global cooperation for clean energy access and invest in sustainable energy infrastructure.	• More than 18.7% households use kerosene as a source of energy for lighting. • Only 61.8% residents have LPG Connection
SDGs Goal 11: SUSTAINABLE CITIES AND COMMUNITIES	**Goal:** • Creating job opportunities, ensuring safe housing, and building resilient communities and economies. • Establishing green public spaces and improving urban planning through inclusive, participatory methods. **Target:** • By 2030, ensure adequate, safe, and affordable housing and services for all, and improve slums. • By 2030, promote inclusive and sustainable urbanization and enhance partic ipatory human settlement planning for all. • By 2030, reduce cities' environmental impact, focusing on air quality and waste management. • By 2030, ensure universal access to safe and inclusive green public spaces for everyone, especially vulnerable groups.	• More than 42.5% houses of the city are in either livable or bad condition. • Only 63.6% household has separate kitchen for cooking

Source: *Compiled from (a) http://www.undp.org.in/indg.htm (b) Census of India, 2011*

Practical Interventions for Basti City and Their Alignment with SDG Targets

1. **Decentralized Water Systems**

- **Intervention:** Establish ward-level rainwater harvesting, decentralized wastewater treatment, and community-managed distribution.
- **SDG Alignment:**
  - SDG 6.1: Ensure universal access to safe and affordable drinking water.
  - SDG 6.3: Improve water quality by reducing pollution and treating wastewater.
  - SDG 11.3: Enhance inclusive and sustainable urban planning.

2. **Community Toilets & Sanitation**

- **Intervention:** Build and maintain hygienic community toilets in high-density neighborhoods, using bio-digester or twin-pit technologies.
- **SDG Alignment:**
  - SDG 6.2: Achieve access to adequate and equitable sanitation for all.
  - SDG 3.9: Reduce illnesses from hazardous water and poor sanitation.
  - SDG 11.1: Ensure access to adequate, safe, and affordable basic services.

3. **Promotion of LPG / Clean Cooking Fuel**

- **Intervention:** Expand LPG coverage through targeted subsidies, last-mile delivery, and awareness programs on the health hazards of biomass and kerosene.
- **SDG Alignment:**
  - SDG 7.1: Ensure universal access to affordable, reliable, and modern energy.
  - SDG 3.9: Reduce deaths and illnesses from air pollution caused by indoor smoke.
  - SDG 13.2: Integrate climate change measures by reducing carbon emissions.

4. **Solid Waste Management Programs**

- **Intervention:** Introduce door-to-door segregated waste collection, ward-level composting, recycling centers, and incentives for segregation.
- **SDG Alignment:**
  - SDG 11.6: Reduce the environmental impact of cities, especially waste management.

- SDG 12.5: Substantially reduce waste generation through prevention, reduction, recycling, and reuse.
- SDG 8.3: Promote inclusive economic opportunities by training youth in waste management.

5. Green Urban Planning

- **Intervention:** Develop urban green belts, rooftop gardens, eco-friendly housing, non-motorized transport corridors, and renewable energy adoption.
- **SDG Alignment:**
  - SDG 11.7: Provide universal access to safe, inclusive, and accessible green public spaces.
  - SDG 13.1: Strengthen resilience to climate-related hazards in urban areas.
  - SDG 15.1: Ensure conservation and sustainable use of terrestrial ecosystems.

Conclusion

The comparative study of Basti city in relation to the United Nations Sustainable Development Goals (SDGs) reveals structural deficiencies in the domains of water, sanitation, energy, waste management, and urban planning. These gaps not only affect the immediate quality of life of the residents but also undermine the city's ability to align with national and international development agendas. To bridge this divide, interventions must be localized, practical, and embedded within the socio-economic realities of Basti, while remaining consistent with the global SDG framework. Decentralized water systems, improved sanitation facilities, and the adoption of clean cooking fuels can provide transformative outcomes for public health and human dignity. Similarly, robust solid waste management initiatives and green urban planning can mitigate environmental degradation while simultaneously generating new livelihood opportunities. The alignment of these interventions with SDG targets ensures that progress in Basti is not isolated, but directly contributes to global development goals such as SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production). However, the effectiveness of these interventions depends on sustained political will, efficient governance, and active community participation. Public–private partnerships, awareness campaigns, and capacity-building programs must be integrated to ensure long-term success. By adopting this multi-pronged approach, Basti city can transform its current challenges into opportunities for sustainable growth. In doing so, it not only addresses critical urban deficiencies but also establishes itself as a model for mid-sized cities in India striving to meet the SDGs by 2030.

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GEOGRAPHICAL ANALYSIS OF THE LEVELS OF SOCIO-ECONOMIC DEVELOPMENT IN THE AGRARIAN ECNOMY OF DARBHANGA, BIHAR

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ABSTRACT

This study investigates spatial differences in socio-economic development within the agrarian economy of Darbhanga district, Bihar. Employing a multi-indicator framework grounded in Geographical Information Systems and Composite Socio-Economic Development Index, the research identifies and analyzes block-level inequalities across five thematic domains: education, health, economy, agriculture, and infrastructure. Secondary data from government sources, including Census 2011, Agricultural Census 2015–16, and Bihar Economic Survey, were standardized using Z-scores to create comparable development profiles across five representative blocks: Darbhanga Sadar, Bahadurpur, Keoti, Benipur, and Hanuman Nagar. Findings reveal stark intra-district disparities. Darbhanga Sadar ranks highest in development due to superior infrastructure and institutional access, while Benipur consistently underperforms, particularly in female literacy, landholding, and health indicators. Hotspot and coldspot analyses using Getis-Ord Gi* statistics confirm the spatial clustering of advantage and deprivation. These results support the assertion that development in rural Bihar remains highly spatialized, echoing earlier observations of socio-economic vulnerability in eastern India. The study advocates for block-specific interventions to bridge regional inequalities and recommends integrating spatial analytics into local planning processes. The findings contribute to the broader literature on regional planning, offering a replicable model for other low-HDI agrarian districts.

Keywords: *Agrarian Economy, Bihar, Composite Index, Darbhanga, GIS, Spatial Disparity*

Introduction

Background and Context

The development of a nation or a region is intricately tied to the spatial and socio-economic attributes of its society. In a predominantly agrarian country like India, where agriculture employs more than half of the population (World Bank, 2021), understanding the geographical and socio-economic development patterns at the micro-regional level is crucial. This is

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especially true for the state of Bihar, which continues to experience a paradox of rich cultural heritage and poor economic development. Within Bihar, the district of Darbhanga stands as a representative unit of rural, agrarian life grappling with socio-economic disparities.

Darbhanga, located in the northern plains of Bihar, belongs to the historically significant Mithila region, and it remains primarily dependent on agriculture, with minimal industrialization or diversification of income sources (Reddy, et al., 2021). Despite several government programs aimed at rural upliftment and infrastructural improvements, significant inter-block disparities in development remain evident. In such a context, analyzing the geographical dimensions of socio-economic development in the agrarian economy of Darbhanga becomes not just an academic inquiry but a policy imperative.

Darbhanga: A Case of Development Paradox

Darbhanga ranks among the districts with a low Human Development Index (HDI) within Bihar. The district has significant agricultural potential due to fertile alluvial soils, yet remains underdeveloped because of frequent flooding, poor irrigation facilities, and lack of institutional credit support (Bihar Economic Survey, 2022). The literacy rate in the district stands at around 60%, which is below the national average, and female literacy lags even further behind (Census of India, 2011).

The workforce structure indicates a high dependency on agriculture, yet there is a predominance of marginal and small farmers, with very few engaged in non-agricultural sectors. Additionally, despite the presence of urban centres like Darbhanga City, many rural blocks remain underdeveloped, reflecting spatial inequality even within a single district.

This research is motivated by the lack of localized, block-level analysis of socio-economic development in Darbhanga. The paper aims to fill this gap by employing quantitative indices, GIS tools, and multi-indicator frameworks to identify spatial disparities and explain the socio-geographical logic behind them. The findings can directly inform district-level policy formulation and resource allocation strategies.

Objectives

1. To assess the current socio-economic status of different blocks in Darbhanga district.
2. To identify spatial disparities in development using composite indices and mapping techniques.
3. To suggest location-specific strategies for balanced rural development.

Theoretical Framework

The present study on the Geographical Analysis of the Levels of Socio-Economic Development in the Agrarian Economy of Darbhanga, Bihar draws upon established theories of regional development, human well-being, and spatial inequality to guide the research design, data interpretation, and policy implications.

Myrdal's Cumulative Causation Theory

According to Gunnar Myrdal (1957), regional disparities persist and widen due to "spread" and "backwash" effects, where developed regions attract more resources and underdeveloped areas face outmigration, low investment, and slow growth. In the context of Darbhanga, uneven socio-economic indicators across blocks reflect such cumulative causation, where infrastructural, educational, and health deficits perpetuate a cycle of underdevelopment.

Core–Periphery Model (Friedmann, 1966)

This model explains spatial inequalities through the dominance of a core area with better economic opportunities, infrastructure, and services, contrasted with peripheral regions that remain economically and socially disadvantaged. Within Darbhanga district, Darbhanga Sadar acts as a potential core, attracting investment and facilities, while blocks such as Bahadurpur or Keoti may remain peripheral.

Amartya Sen's Capability Approach

Sen's human development perspective emphasizes that development is not merely about income but about expanding people's capabilities and freedoms—such as access to education, healthcare, and infrastructure. This approach justifies the inclusion of multiple indicators—literacy, healthcare access, employment, and infrastructure—in measuring socio-economic development.

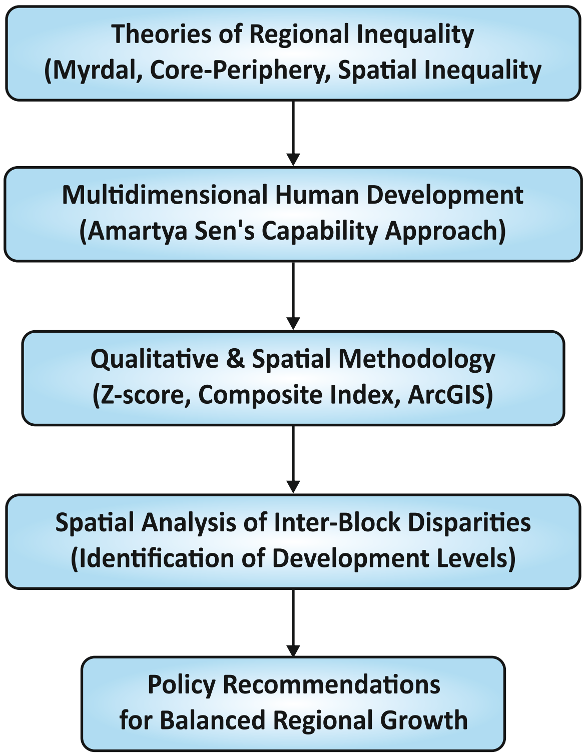
Integration with Spatial and Statistical Tools

To operationalize these theories, the study employs Z-score standardization to normalize data across diverse indicators and composite index construction to classify development levels. ArcGIS-based spatial analysis maps these disparities, providing visual evidence of core-periphery patterns and cumulative causation effects.

Development Approach, as advocated by UNDP (1990) and further developed by Amartya Sen (1999), emphasizes the role of education, health, and social participation in defining development. In contrast, Dependency Theory suggests that peripheral regions like rural Bihar remain underdeveloped due to systemic This study is guided by Human Development Theory and Dependency Theory. The Human neglect and poor integration into national markets (Frank, 1967).

Both frameworks highlight the need for localized development models, informed by geographical realities. This study aligns with this thinking by adopting a block-level analytical approach, grounded in regional data, to understand the multi-dimensional nature of development.

Theoretical Framework : Spatial Analysis of Socio-Economic Development in Darbhanga



Relevance and Policy Significance

A granular understanding of development patterns in Darbhanga has immense policy relevance. The Government of Bihar, under schemes like the Mukhyamantri Gramin Sadak Yojana, Bihar Vikas Mission, and Bihar State Food and Nutrition Security, aims to create equitable development. However, without micro-level spatial analysis, many blocks continue to be underserved.

Findings from this study can contribute to:

- Better targeting of development schemes at the block or Panchayat level.
- Supporting evidence-based rural planning and disaster management.
- Enhancing academic knowledge in development geography.

Methodology

Research Approach

This research adopts a quantitative, spatial analytical approach to assess the level of socio-economic development across selected blocks of Darbhanga district in Bihar. The research applies a regional micro-level framework, utilizing geographical information systems (GIS) and a Composite Socio-Economic Development Index (CSEDI) to evaluate and map disparities across the region.

The methodological steps include:

1. Indicator selection and data compilation
2. Z-score standardization and index construction
3. Spatial analysis using ArcGIS

This approach enables a multi-dimensional understanding of development through both quantitative and cartographic lenses.

Data Sources

The present study is based entirely on secondary data, which refers to information collected by other researchers, institutions or agencies for purposes other than the current study. The secondary data for this study has been obtained from reliable official publications such as:

- Census of India 2011
- District Statistical Handbook (Darbhanga, 2022)
- Agricultural Census 2015–16
- Bihar Economic Survey (2021–2023)
- Rural Health Statistics (Ministry of Health & Family Welfare)
- Remote sensing and GIS shapefiles from Bhuvan (ISRO) and NIC

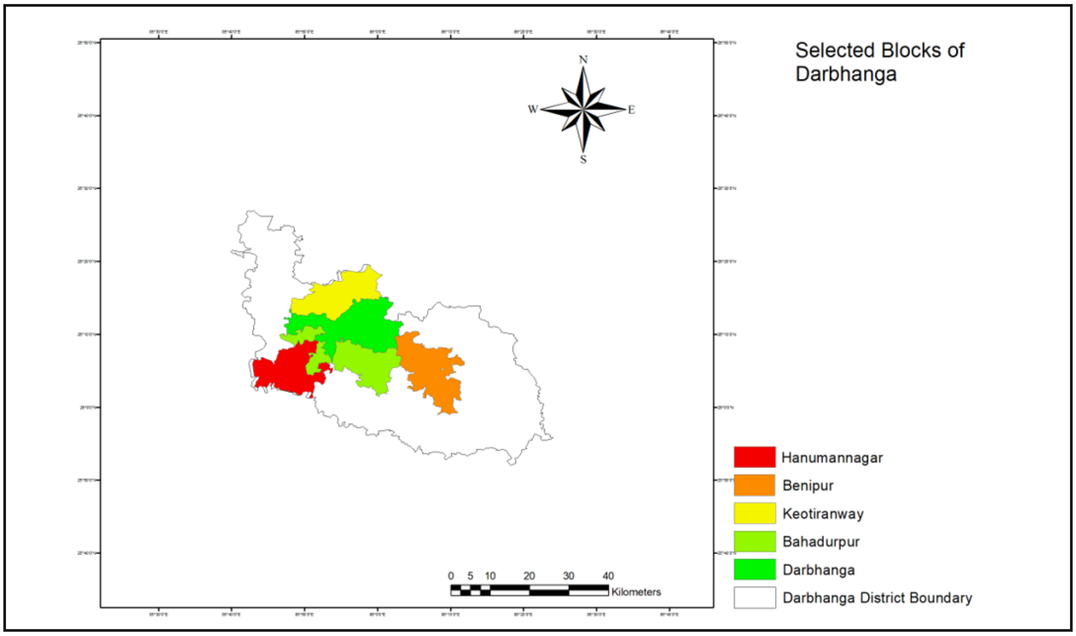
These sources were selected on the basis of their authenticity, reliability, and relevance to the research objectives.

Study Area and Units of Analysis

The research focuses on five representative blocks within Darbhanga district:

- Darbhanga Sadar
- Keoti
- Hanuman Nagar
- Bahadurpur
- Benipur

These blocks were chosen for their distinctive demographic, agrarian, and infrastructural characteristics, making them suitable proxies for analyzing the intra-district development landscape. Each block is treated as a separate spatial and statistical unit for comparison and mapping.



(*Source:* *Prepared by the Authors*)

Figure 1: Study Area Map of Selected Blocks in Darbhanga District Using ArcGIS

Indicators Used

Table 1: Ten socio-economic indicators were selected and categorized under five themes

Theme	Indicators
Education	Literacy Rate, Female Literacy Rate
Health	Number of PHCs, Institutional Birth Rate
Economy and Employment	Main Workers (%), Marginal Workers (%)
Agriculture and Land Use	Avg. Landholding Size, Net Sown Area (%)
Infrastructure	Road Density, Electricity Access (%)

*(**Source:** Census of India (2011), Agricultural Census 2015–16, Bihar Economic Surve, 2022–23, and Rural Health Statistics; Ministry of Health & Family Welfare, 2021).*

Composite Index Construction

The CSEDI was built using the Z-score method, which standardizes values across indicators to make them statistically comparable:

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{\sigma_j}$$

Where:

- Z_{ij} Is the standardized score of the indicator j in block i.
- X_{ij} Is the actual value of the indicator
- $\bar{X}_j$ Is the mean of the indicator j
- σ_j is the standard deviation of the indicator j

The sum of all standardized indicator values for each block formed the composite score, which was then used for ranking blocks and identifying their relative development levels.

GIS-Based Spatial Analysis

GIS analysis was performed using ArcGIS 10.8, involving:

- Import of block boundary shapefiles
- Linking socio-economic data via attribute joins
- Generating choropleth maps to depict development zones
- Performing *hotspot (Getis-Ord Gi) analysis** to detect clusters of high/low development

Ethical and Validation Measures

All data used were secondary and publicly available. Cross-validation was conducted using at least two separate sources for each indicator. Maps were validated against available district atlases and survey maps.

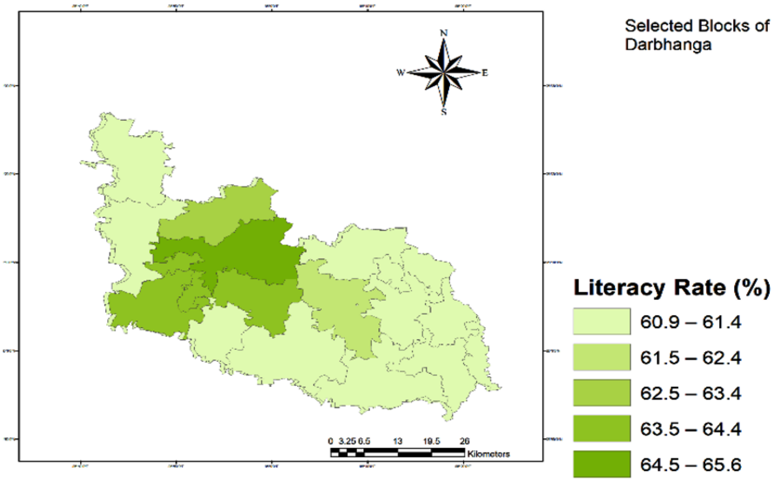
Result and Discussion

Table 2: Demographic and Literacy Profile of Blocks in Darbhanga District

Block Name	Population	Male Literacy (%)	Female Literacy (%)	Total Literacy (%)
Darbhanga Sadar	245,312	72.4	58.7	65.6
Bahadurpur	218,905	71.3	55.6	63.4
Keoti	232,194	69.9	54.8	62.6
Benipur	205,789	68.2	53.3	60.9
Hanuman Nagar	198,543	70.1	56.7	63.1

*(**Source:** Registrar General & Census Commissioner of India. (2011). District Census Handbook: Darbhanga. Ministry of Home Affairs, Government of India.)*

Table 2 presents the demographic and literacy profile of five key blocks in Darbhanga district, revealing significant inter-block disparities. Darbhanga Sadar, with a population of 245,312, records the highest overall literacy rate (65.6%), attributed to its semi-urban character and better access to education. In contrast, Benipur and Keoti exhibit lower literacy rates, especially among females (53.3% and 54.8%, respectively), highlighting persistent gender gaps in rural Bihar (Dreze & Sen, 2013).



*(**Source:** Prepared by the Authors)*

Figure 2: Literacy and Female Literacy Rates Across Blocks in Darbhanga District

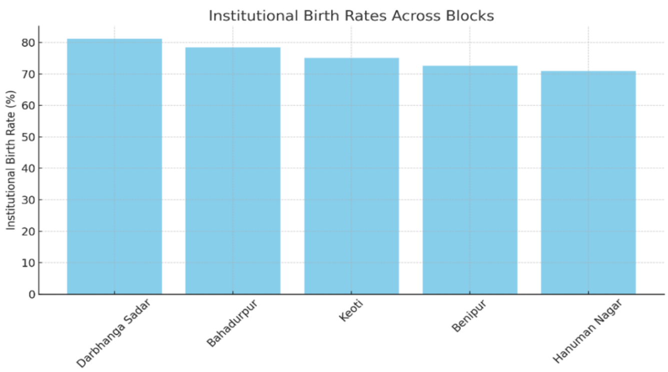
These patterns align with findings from the Census of India (2011), which reported widespread educational deprivation in agrarian districts. The data underscores the need for targeted literacy interventions, particularly in blocks with substantial gender disparities and rural backwardness.

Table 3: Block-wise Distribution of Primary Health Infrastructure and Institutional Birth Rates in Darbhanga District

Block Name	No. of PHCs	No. of CHCs	Institutional Birth Rate (%)
Darbhanga Sadar	3	1	81.2
Bahadurpur	2	1	78.4
Keoti	2	1	75.1
Benipur	2	1	72.6
Hanuman Nagar	1	1	70.9

*(**Source:** Ministry of Health & Family Welfare (MoHFW). (2021). Rural Health Statistics 2020–21. Government of India.)*

The table demonstrates how primary healthcare facilities differ between Darbhanga's selected blocks. The three Primary Health Centres (PHCs) in Darbhanga Sadar along with an 81.2% institutional birth rate demonstrate superior maternal and neonatal healthcare services. The single PHC in Hanuman Nagar serves as the main reason for its lowest institutional birth rate of 70.9% because it restricts access to safe delivery facilities. The government has confirmed that the density of health infrastructure directly impacts maternal health results (Ministry of Health & Family Welfare, 2021). The persistent lack of healthcare infrastructure in Benipur and Keoti blocks underscores the immediate requirement for local health funding because institutional deliveries in rural Bihar fall short of national benchmarks (IIPS & MoHFW, 2021).



*(**Source:** Prepared by the Authors)*

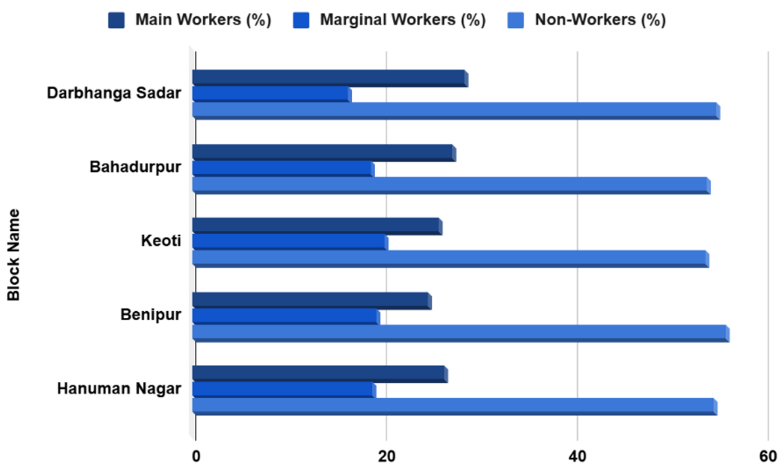
Figure 3: Institutional Birth Rates Across Blocks in Darbhanga District

Table 4: Block-wise Occupational Structure in Darbhanga District Based on Workforce Participation

Block Name	Main Workers (%)	Marginal Workers (%)	Non-Workers (%)
Darbhanga Sadar	28.6	16.4	55.0
Bahadurpur	27.3	18.7	54.0
Keoti	25.9	20.2	53.9
Benipur	24.7	19.3	56.0
Hanuman Nagar	26.4	18.9	54.7

*(**Source:** Registrar General & Census Commissioner of India. (2011). District Census Handbook: Darbhanga. Ministry of Home Affairs, Government of India.)*

Table 4 outlines the occupational distribution across the five selected blocks in Darbhanga district, offering insights into patterns of workforce participation. A close look at the data reveals that Darbhanga Sadar has the highest proportion of main workers (28.6%), suggesting better employment stability, likely influenced by its semi-urban infrastructure and access to formal job markets. In contrast, Benipur, with the lowest main worker percentage (24.7%) and a relatively high share of marginal workers (19.3%), indicates prevalent underemployment and seasonal labor dependency, reflecting structural constraints in its rural economy.



*(**Source:** Prepared by the Authors)*

Figure 4: Block-wise Occupational Structure in Darbhanga District Based on Workforce Participation

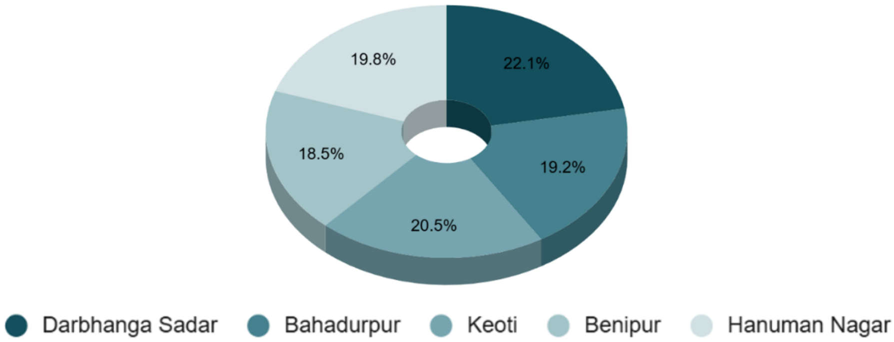
Keoti stands out with the highest marginal worker percentage (20.2%), which may be attributed to irregular agricultural and informal sector employment, common in blocks with a predominantly agrarian base but limited value addition or secondary sector diversification. Meanwhile, Bahadurpur and Hanuman Nagar exhibit a balanced pattern between main and marginal workers, though both have non-worker populations exceeding 54%, underscoring the demographic burden on the active labor force. The consistently high proportion of non-workers across all blocks, particularly in Benipur (56.0%), signifies latent labor potential and points to barriers such as low female workforce participation, skill mismatches, and limited rural enterprise development. These observations align with the findings of the Census of India (2011), which emphasizes significant gender and rural-urban gaps in labor force participation across Bihar. Furthermore, the regional disparities in occupational structure reflect broader socio-economic imbalances as noted by Dreze and Sen (2013), where employment vulnerability coexists with agrarian distress in eastern India.

Table 5: Agricultural Characteristics of Blocks in Darbhanga District: Landholding Size, Net Sown Area, and Irrigation Coverage

Block Name	Avg. Landholding Size (ha)	Net Sown Area (%)	Irrigated Area (%)
Darbhanga Sadar	0.68	72.1	61.4
Bahadurpur	0.59	70.3	60.1
Keoti	0.63	75.6	62.3
Benipur	0.57	68.7	59.2
Hanuman Nagar	0.61	71.4	60.9

*(**Source:** Government of Bihar. (2023). Bihar Economic Survey 2022–23. Finance Department, Government of Bihar.)*

The agrarian profile of Darbhanga blocks reveals small average landholdings between 0.57 to 0.68 hectares which demonstrates land fragmentation as a major obstacle to rural prosperity in Bihar (Government of India, 2016). The efficient land management in Keoti leads to the highest net sown area (75.6%) and irrigation coverage (62.3%) despite its small landholdings.



*(**Source:** Prepared by the Authors)*

Figure 5: Agricultural Characteristics of Blocks in Darbhanga District: Landholding Size, Net Sown Area, and Irrigation Coverage

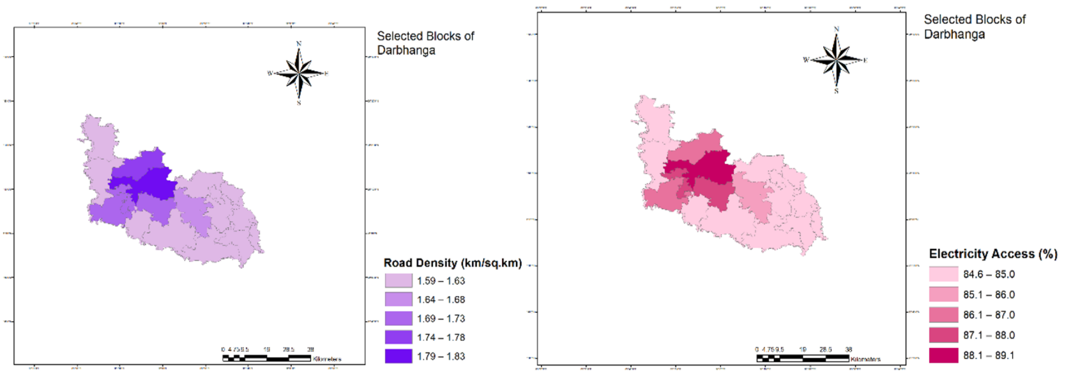
The average land size of 0.57 hectares in Benipur correlates with the lowest irrigation coverage rate at 59.2% which demonstrates structural weaknesses in agricultural productivity. The data confirms Singh et al. (2020) who demonstrate that land dimensions together with irrigation systems determine agricultural outputs in eastern India. The combination of better micro-irrigation systems and land consolidation programs would create substantial improvements in rural economic conditions within these landscapes with smallholder farming systems.

Table 6: Block-wise Physical Infrastructure in Darbhanga District: Road Density and Electricity Access

Block Name	Road Density (km/sq.km)	Electricity Access (%)
Darbhanga Sadar	1.82	89.1
Bahadurpur	1.65	87.3
Keoti	1.73	85.9
Benipur	1.59	84.6
Hanuman Nagar	1.68	86.2

*(**Source:** Government of Bihar. (2023). Bihar Economic Survey 2022–23. Finance Department, Government of Bihar)*

The table shows how physical infrastructure levels differ between blocks in Darbhanga which serves as a vital indicator for rural development. The block of Darbhanga Sadar stands out for its superior infrastructure because it has the highest road density (1.82 km/sq.km) and electricity access (89.1%) which indicates its successful combination of urban and rural areas.



*(**Source:** Prepared by the Authors)*

Figure 6: **Road Density and Electricity Access Across Blocks in Darbhanga District**

The infrastructure levels in Benipur remain the lowest among all blocks which indicates ongoing spatial inequality persists in the area. The infrastructure deficits in Bihar match the conclusions presented in the Planning Commission report (Planning Commission, 2014). The World Bank (2018) explains that electricity and roads serve as basic requirements to access education & health facilities and markets. The infrastructure performance of Keoti and Hanuman Nagar blocks falls between average and below average which indicates that these areas require equal investments to improve transportation and service delivery in disadvantaged areas.

Table 7: Z-Score Normalized Values of Socio-Economic Indicators and Composite Scores for Blocks in Darbhanga District

Block Name	Z-Score Literacy	Z-Score Health	Z-Score Economy	Z-Score Agriculture	Z-Score Infrastructure	Total Z-Score
Darbhanga Sadar	0.88	1.02	0.91	0.86	1.04	4.71
Bahadurpur	0.57	0.84	0.73	0.65	0.92	3.71
Keoti	0.41	0.68	0.56	0.95	0.83	3.43
Benipur	0.23	0.52	0.48	0.62	0.74	2.59
Hanuman Nagar	0.51	0.61	0.61	0.79	0.85	3.37

*(**Source:** Author's calculation based on standardized scores using data from secondary sources including Census 2011, Agricultural Census 2015–16, Rural Health Statistics 2021, and Bihar Economic Survey 2022–23)*

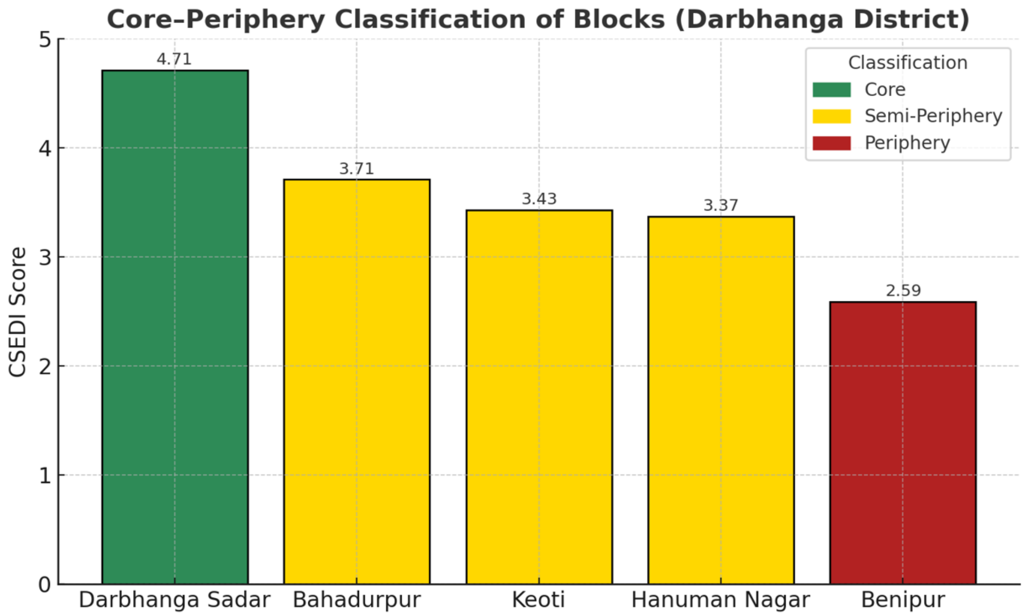
The standardized Z-scores for five development dimensions show the selected blocks in Darbhanga through this table. The block of Darbhanga Sadar stands out as the most developed area because its composite Z-score reaches 4.71 which results from robust infrastructure and health and education performance. The multi-dimensional underdevelopment of Benipur becomes evident through its total Z-score value of 2.59. Z-score normalization allows stakeholders to compare effectively since it removes measurement unit differences (Das, 2004). Keoti demonstrates superior performance in agricultural development (Z = 0.95) while showing weakness in both literacy and economic sectors (Z = 0.95 and Z = 0.95 respectively) which indicates sectoral imbalances. The integrated analysis confirms the research of Basu and Das (2021) by demonstrating how composite indices effectively identify rural deprivation. The scores serve as a basis for selecting areas for focused development planning.

Table 8: Classification of Blocks in Darbhanga District by Composite Socio-Economic Development Index (CSEDI)

Block Name	CSEDI Score	Development Category
Darbhanga Sadar	4.71	High
Bahadurpur	3.71	Medium
Keoti	3.43	Medium
Hanuman Nagar	3.37	Medium
Benipur	2.59	Low

*(**Source:** Author's computation using Z-score index constructed from multi-indicator data sets sourced from Census 2011, Bihar Economic Survey, and Agricultural Census 2015–16.)*

The table shows the Composite Socio-Economic Development Index (CSEDI) scores which rank blocks in Darbhanga through multidimensional indicators. The highest-ranking block in the district is Darbhanga Sadar which achieved a score of 4.71 because it demonstrated steady performance in education as well as health infrastructure and economic sectors. The lowest CSEDI score of 2.59 belongs to Benipur which demonstrates widespread development deficiencies throughout its sectors. Through the CSEDI multiple indicators can be combined into a unified metric which helps both spatial and policy-focused assessments (Kundu et al., 2021). The middle-ranking blocks Keoti and Hanuman Nagar demonstrate the diverse nature of rural Bihar which requires specific planning approaches for each block (Singh et al., 2022). National objectives for evidence-based development gain support from these rankings which seek to address regional inequality.



Source: *Compiled by the author using data from Census of India (2011); Agricultural Census (2015–16); Bihar Economic Survey (2022–23); Rural Health Statistics, Ministry of Health & Family Welfare (2021).*

Table 9: Spatial Cluster Analysis of Development Levels in Darbhanga District Using Getis-Ord Gi Statistics*

Block Name	Cluster Type	Z-Score	P-Value
Darbhanga Sadar	Hotspot	2.31	0.010
Bahadurpur	Hotspot	1.98	0.024
Keoti	Neutral	1.34	0.089
Benipur	Coldspot	-2.07	0.038
Hanuman Nagar	Neutral	0.79	0.136

*(**Source:** Spatial analysis performed by author using ArcGIS 10.8 software and shapefiles from ISRO Bhuvan and NIC.)*

This summary provides spatial clustering data of development measured by Getis-Ord Gi statistics* to identify blocks with significant development distributions. The statistical analysis indicates that Darbhanga Sadar and Bahadurpur show significant socio-economic advantage concentrations ($Z = 2.31$ and 1.98 respectively; $p < 0.05$). The Getis-Ord Gi statistics show Benipur as a coldspot ($Z = -2.07$) because it demonstrates clustered deprivation across space. The areas of Keoti and Hanuman Nagar show no significant clustering patterns. The spatial pattern confirms Basu and Das (2021) who demonstrated that development disparities tend to show geographic continuity. Geographic information systems enable planners to detect crucial target areas which enables them to distribute resources effectively (Kang-tsung & Li, 2016) so planners can develop precise regional strategic plans.

Location-specific strategies for balanced rural development

Darbhanga district is flood-prone (76% of population under recurring flood threat) researchgate.net, so Bahadurpur's strategy emphasizes **flood-resilience** (flood-tolerant crops, raised shelters) alongside livelihood support (SHGs, aquaculture), Because Bahadurpur has low-lying, flood-exposed village cluster with small holdings — needs resilience + income alternatives.

Hanuman nagar block is a good unit for infrastructure & skill investments as it faces block-level service gaps (markets, health, irrigation etc.) and Keoti block is the origin of seasonal migration and under-utilised local labour — need local wage-intensive work and processing. So Hanuman Nagar and Keoti focus on market/infrastructure and skills to **diversify livelihoods** (irrigation, skill hubs, agro-processing).

Darbhanga Sadar has highest multiplier effect — connecting rural producers to city demand and services so it highlights rural–urban linkages (cold-chain and craft value chains, waste management), and Benipur block has better road/rail access and cultural sites — potential for tourism-linked income and value-addition so Benipur targets tourism and crop value-addition plus **flood preparedness**.

Recommendations for the study area

- Flood risk zoning for housing & infrastructure planning and promote flood-resilient agriculture (short-duration paddy, maize, pulses)
- Establish farmer training & demonstration centres like Vocational training in IT, retail, and tourism services and introduce ICT-based farmer advisory services
- Heritage-based tourism circuits linked to Darbhanga city
- Improve drainage and rural roads to market points as urban-rural linkage (farm-to-market logistics hubs) and develop rural haats into permanent market complexes

- Promote women's SHGs and introduce skill development for women in handicrafts, tailoring, food processing & pickle making
- Develop small-scale agro-processing units (mustard oil, rice mills) and Strengthen dairy cooperatives and cold storage facilities
- Upgrade health & sanitation infrastructure in low-lying villages and build embankments and check-dams for water management
- Improve irrigation through solar-powered pumps.
- Promote youth entrepreneurship through microfinance
- Large-scale mango, litchi & makhana plantation clusters and expand fishery & aquaculture with modern techniques along with vegetable cultivation under polyhouse conditions

Conclusion

The research shows that five blocks within Darbhanga district in Bihar exhibit significant differences in their socio-economic development levels. The Composite Socio-Economic Development Index (CSEDI) shows that Darbhanga Sadar block maintains superior performance compared to other blocks because of its strong infrastructure and literacy and healthcare indicators. The area of Benipur shows multiple signs of underdevelopment through its insufficient female literacy rates poor health services minimal irrigation systems and weak infrastructure. The development status of Bahadurpur, Keoti and Hanuman Nagar blocks lies in the medium range yet these areas need specific interventions to address their sectoral inequalities. The Z-score normalization and GIS-based hotspot analysis demonstrate spatial clustering of development and deprivation through statistical evidence showing that Darbhanga Sadar and Bahadurpur represent hotspots but Benipur requires immediate attention as a coldspot. The research results validate the established concept that rural development in India shows both unevenness and spatial patterns. The recommendations outlined—ranging from flood-resilient agriculture in Bahadurpur, agro-processing and cooperative strengthening in Hanuman Nagar, aquaculture and water management in Keoti, urban–rural linkages and heritage-based tourism in Darbhanga Sadar, to horticulture and women-led enterprises in Benipur—emphasize the importance of local resources and community participation.

Collectively, these strategies aim to enhance livelihood opportunities, improve infrastructure, promote women and youth empowerment, and ensure environmental sustainability. By addressing both the vulnerabilities (such as recurrent floods, inadequate market access, and low skill levels) and the untapped potentials (like fisheries, horticulture, tourism, and handicrafts), the proposed measures seek to achieve balanced and inclusive growth across the region.

Thus, the study underlines that integrated planning, supported by government schemes, community-based organizations, and CSR initiatives, can bridge rural-urban disparities and set a roadmap for long-term sustainable development in Darbhanga.The research demonstrates the necessity of evidence-based policies which consider geographical factors and establish a model that other districts with similar socio-economic development inequalities can adopt.

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A CRITICAL STUDY OF STRUCTURAL FLOOD MANAGEMENT MEASURES AND THEIR ENVIRONMENTAL IMPACTS: A CASE STUDY OF BUXAR DISTRICT, BIHAR

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ABSTRACT

Floods constitute one of the most recurrent and disruptive natural hazards in India, particularly across the Gangetic plains. The state of Bihar, owing to its geographical and hydrological features, frequently suffers from annual inundations, with Buxar district being a prime example due to its proximity to the Ganga River and its tributaries.

This study critically evaluates the structural flood management interventions, such as embankments, drainage infrastructure, and high dams, implemented in Buxar, and assesses their environmental implications at the local level. Drawing from a combination of primary field surveys, government publications, and observational data, the research reveals that while these structures have offered partial protection against floodwaters, they have simultaneously triggered environmental disturbances, including altered river regimes, chronic waterlogging, soil degradation, and biodiversity loss.

The findings underscore that a solely infrastructure-based approach to flood management is inadequate and ecologically unsustainable. Therefore, a hybrid strategy that integrates structural engineering with non-structural measures, such as community-based planning, sustainable land use, and ecosystem restoration, is imperative for long-term resilience.

Keywords: *Disaster Risk Reduction, ecological impact, embankments, environmental degradation, flood management, structural measures.*

Introduction

Natural disasters have accompanied human civilization since its earliest days. Among these, floods stand out as the most recurrent and widespread hazard. According to The Human Cost of Natural Disasters (CRED, 2015), floods accounted for nearly 43% of all global disasters between 1994 and 2013. During this period, over 2.5 billion people were affected, and the

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estimated economic losses exceeded USD 636 billion (CRED, 2015)—placing floods among the top three most destructive natural disasters worldwide, alongside cyclones and earthquakes.

In recent decades, the increasing frequency and intensity of floods can be attributed to the accelerating impacts of climate change, deforestation, unplanned urban expansion, and large-scale concretization to meet the demands of a growing population (UNEP, 2020;Bradshaw et al., 2007). In India, the National Policy on Disaster Management (NPDM, 2007) identifies nearly 40 million hectares—approximately 12% of the country's landmass—as flood-prone. The burden of such disasters disproportionately falls on socially and economically marginalized communities, making them the most vulnerable.

Flood management has long been a central concern for human settlements. Over the years, various structural interventions—such as embankments, levees, sea walls, barrages, artificial reservoirs, flood gates, and diversion channels—have been adopted to mitigate flood risks. Although these engineering measures offer short-term relief and localized protection, they often interfere with the natural hydrological dynamics of rivers, particularly when implemented without ecological foresight.

The Ganga River, regarded as the lifeline of India, flows through five states including Bihar and is fed by numerous tributaries along its course. The river routinely experiences seasonal flooding, especially during the monsoon, which brings both beneficial and detrimental effects. However, in the absence of community awareness and sustainable planning, the adverse impacts of flooding tend to outweigh the benefits. With over 900 dams and barrages constructed across India (The Economic Times, 2018, November 24), the long-term ecological integrity of the Ganga river system now faces substantial threats.

In Bihar, the Ganga enters the state through the Chausa block of Buxar district, accompanied by tributaries such as the Karmanasha, Dharmavati, Kao, and Thora rivers. These collectively render Buxar highly susceptible to flooding. Yet, structural interventions designed to manage floods in the region have often disrupted natural flow regimes, altered drainage patterns, and adversely affected the local environment (Disaster Management Division, Buxar, 2022).

Flood management should not be constrained by administrative boundaries alone. River systems transcend political borders, flowing through entire watersheds from source to outlet. Therefore, structural flood control strategies must be assessed through the lens of long-term ecological sustainability and basin-wide hydrological coherence, rather than short-term administrative priorities.

Below is a summary of major structural interventions undertaken in Buxar district:

Table 1: Location-wise Overview of Structural Flood Management Measures in Buxar District

Location/Area	Type of Structural Measure
Ganga River system in Buxar	(a) Construction of embankments such as Buxar–Koilwar and Saran embankments
Canal and drainage network	(b) Construction of drainage canals and stormwater outlets
Karhansi and Brahmpur regions	(c) Barrages and flood-control reservoirs
Riverside villages (e.g., Umarpur, Tiwai)	(d) Erosion-control measures including stone gabions, geo-bags, pontoon bridges, and afforestation

Source: *Field Survey (2023-2024)*

Objectives

This research aims to undertake a comprehensive and multidimensional evaluation of the structural measures implemented for flood management in the Buxar district, with particular emphasis on their long-term environmental implications. The specific objectives of this study are:

1. To identify the structural flood control measures adopted in Buxar district and assess them within relevant technical and geographical frameworks.
2. To investigate the environmental consequences of these interventions—especially their influence on river hydrodynamics, groundwater recharge, soil erosion, biodiversity, and overall ecological balance.
3. To evaluate the effectiveness and long-term sustainability of structural measures in mitigating flood frequency and enhancing the adaptive resilience of local communities.
4. To offer policy-oriented recommendations for planners, administrators, and decision-makers aimed at developing more sustainable, environmentally sensitive, and contextually appropriate flood management strategies.

Scope and Limitations of the Study

This study is both geographically and thematically centered on the flood-prone regions of Buxar district in Bihar, predominantly affected by the Ganga River and its tributaries. The design of this research recognizes several conceptual and methodological boundaries, as outlined below:

***Geographical Scope*:** The study is limited to the Buxar district, focusing specifically on villages located along the banks of the Ganga and its tributaries that experience recurrent flooding.

Topical Scope: The investigation is restricted to structural flood management measures—such as embankments, barrages, and drainage systems. Non-structural approaches are referenced only as supportive or comparative contexts.

Data Sources: The analysis is based on a mix of primary data (gathered through field surveys) and secondary data (government publications, scholarly research, census records, and official reports).

Analytical Limitations: Although the study emphasizes environmental impacts, socio-cultural dimensions are addressed only to a limited extent.

Despite these defined boundaries, the research provides an in-depth and contextually relevant understanding of the performance and ecological effects of structural flood control mechanisms in the Buxar district.

Literature Review

Previous Studies on Flood Management

Scholars worldwide have long emphasized that floods, though natural, are often aggravated by human activities such as deforestation, encroachment, and unplanned land use (Smith & Ward, 1998). Official reports show that by March 2011, India had constructed about 35,200 km of embankments, which rose to 37,073 km by 2017 (Planning Commission, 2012; CWC, 2018; NITI Aayog, 2021). While these offered partial protection, they also generated problems of sedimentation, waterlogging, and environmental stress. Global agencies including the IPCC (2014) and UNDP (2020) highlight that reliance on engineering solutions alone is insufficient, recommending instead integrated approaches that combine infrastructure with climate adaptation, community participation, and ecologically sensitive planning.

Structural Measures in Global and National Contexts

International experiences present mixed outcomes. In the United States, levees along the Mississippi, the Netherlands' Delta Works, and China's Three Gorges Dam initially reduced flood risks but later caused sedimentation, ecological imbalance, and large-scale displacement (Kundzewicz et al., 2019; Freie Universität Berlin, 2023; Luo, Yang, & Zhang, 2012). By contrast, Bangladesh demonstrates a hybrid model where embankments are complemented by early warning systems, resettlement planning, and community participation, enhancing long-term resilience (Halls, Welcomme, & Burn, 2008).

In India, despite large-scale investments since the 1950s, flood losses have not declined significantly. The case of Bihar's Kosi and Gandak rivers illustrates the paradox: embankments have reduced exposure in some areas but intensified flooding in others (FICCI, 2018; Kumar, 2015).

Relevant Studies in Buxar District

Though academic work on Buxar is limited, official reports provide critical evidence. The Bihar Flood Management Report (2021) documents that embankments protected some villages but caused poor drainage and waterlogging. The CGWB Annual Report (2020) shows declining groundwater recharge due to extensive canal and embankment systems, while the Bihar Biodiversity Board (2019) notes the degradation of wetlands and oxbow lakes vital for migratory birds and aquatic diversity. Collectively, these findings suggest that structural interventions in Buxar reduce immediate flood exposure but undermine ecological stability, highlighting the need for hybrid approaches that integrate structural safety with biodiversity protection and community engagement.

Research Methodology

This study adopted a multi-method design to assess the environmental consequences of structural flood management measures in Buxar district, Bihar. Quantitative surveys generated socio-economic indicators, while qualitative methods such as interviews and focus group discussions captured community perceptions. In addition, geospatial analysis using GIS and remote sensing enabled spatial mapping of flood-prone areas, embankments, and ecological changes over time. Together, these methods ensured a comprehensive and evidence-based understanding of flood impacts.

Research Design

The research followed a descriptive–analytical framework to document and critically analyze the socio-ecological impacts of structural interventions. Methods included:

- Household surveys (questionnaire-based)
- In-depth interviews with residents and officials
- Focus Group Discussions (FGDs) with community members
- GIS- and remote sensing-based spatial analysis

The study period extended from May 2023 to October 2024, covering two consecutive monsoons. This temporal scope enabled comparison across years, highlighting both short-term and immediate changes in ecological and socio-economic conditions.

Study Area

(a) Geographical Context

Buxar district lies in western Bihar (25°15′N to 25°44′N latitude; 83°58′40″E longitude). Traversed by the Ganga and tributaries such as the Karmanasha, Dharmavati, and Kao, the district experiences annual flooding due to upstream rainfall, sediment deposition, and declining river capacity.

Table 2: Flood-Affected Administrative Units in Buxar District (2019–2022)

Year	Affected Blocks	No. of Affected Panchayats	No. of Affected Villages	Affected Population
2019	Buxar, Chausa, Itarhi, Brahmpur, Chakki, Simri	18	46	22,000
2021	Buxar, Chausa, Itarhi, Brahmpur, Chakki, Simri, Rajpur, Dumraon	55	96	26,600
2022	Buxar, Chausa, Itarhi, Brahmpur, Chakki, Simri	16	39	1,500

Source: *Disaster Management Branch, Buxar (2022)*

(b) Selected Flood-Affected Villages

Four villages were purposively chosen for recurrent flood exposure, severity of damage, and presence of mitigation infrastructure. One non-flood village was added as a control for comparative analysis.

Table 3: Selected Flood-Affected Villages in Buxar District

Village Name	Block	Major Flood-Related Issues
Umarpur Diara	Buxar	Embankment erosion,
Nainijor	Brahmpur	Loss of agricultural land due to erosion
Jawahi Diara	Chakki	Frequent displacement and resettlement needs
Tiwai	Chausa	Disruption of roads and transportation services

Source*: Field Survey (2023–2024)*

(c) GIS Mapping of the Study Villages

Geospatial mapping was conducted for all selected villages using QGIS 3.22 and ArcGIS 10.8. Spatial data layers included embankments, drainage networks, settlements, and river buffers. Satellite imagery from Landsat-8 OLI (30 m) and Sentinel-2 MSI (10 m) was processed for land-use and waterbody classification. Hydrological features were analyzed through NDWI (McFeeters, 1996) and supervised classification, enabling identification of flood-prone zones, waterlogging areas, and ecological impacts of structural interventions.

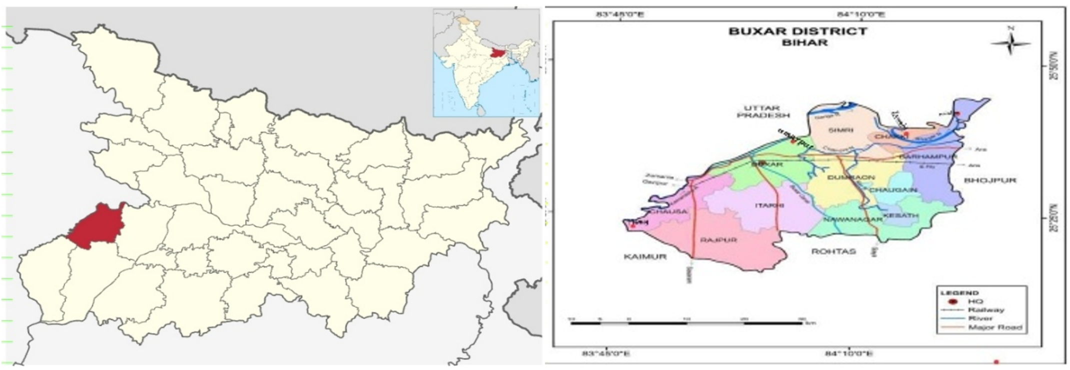


Figure 1: Selected Flood-Affected Villages in Buxar District, Bihar

Data Collection Methods

(a) Primary Data

A semi-structured questionnaire (pilot-tested for clarity) was administered to 200 households—50 from each of the four flood-affected villages. Purposive random sampling ensured inclusion of marginalized groups such as SC/ST communities, women-headed households, small farmers, and fisherfolk. Complementary qualitative methods included FGDs (10–12 participants per village) and Key Informant Interviews (with Panchayat leaders, SHG members, elderly residents, and local officials), capturing lived experiences, coping strategies, and ecological perceptions.

(b) Secondary Data

To support primary findings, multiple sources were used:

Government Reports: DDMP Buxar (2022), BSDMA documents, Flood Control Board records.

Census & Hydrological Data: Census 2011, CGWB reports, rainfall–runoff records.

Geospatial Data: Landsat-8 OLI (30 m) and Sentinel-2 MSI (10 m) imagery, processed in QGIS 3.22 and ArcGIS 10.8. NDWI (McFeeters, 1996) and supervised classification methods were applied to delineate flood-prone areas, vegetation cover, and floodplain changes (Drusch et al., 2012).

This combination of field surveys + FGDs/KIIs + geospatial data provided both socio-economic depth and ecological breadth.

Data Analysis Techniques

A mixed-method strategy integrated quantitative, geospatial, and qualitative analyses:

(a) Quantitative Analysis

Household survey data were coded and analyzed in SPSS v26 and Excel, using frequencies, cross-tabulations, descriptive statistics, and correlation tests (e.g., flood exposure vs. income loss, migration, or service access).

(b) Geospatial Analysis

Satellite datasets (Landsat-8 OLI/TIRS and Sentinel-2 MSI) were processed using QGIS and ArcGIS environments to generate thematic layers of embankments, drainage patterns, and settlements. Spectral indices such as NDWI (Normalized Difference Water Index) and NDVI (Normalized Difference Vegetation Index) were applied to delineate waterlogged areas and monitor vegetation dynamics. Supervised classification and overlay analysis were employed to correlate structural interventions with ecological indicators, including groundwater recharge, aquatic vegetation cover, and siltation patterns.

(c) Qualitative Analysis

FGD and interview transcripts were coded thematically, highlighting perceptions of flood risk, relief measures, ecological degradation, and governance.

(d) Triangulation

Cross-verification of quantitative, geospatial, and qualitative results enhanced reliability, ensuring a holistic interpretation of structural measures and their ecological–livelihood intersections.

Ethical Considerations

Ethical integrity was maintained throughout the research process to ensure reliability and respect for participants. Informed consent was obtained from all respondents prior to data collection, and participation was entirely voluntary. To safeguard ethical standards, the following measures were consistently applied:

- ❖ Privacy and dignity of participants were strictly respected, with anonymity maintained in reporting.
- ❖ No monetary or material incentives were offered, ensuring voluntary participation free from coercion.

- ❖ Sensitive issues, particularly in discussions with women and marginalized groups, were addressed with cultural appropriateness and care.

These practices align with established ethical research guidelines and helped create a respectful and trustworthy environment for data collection.

Limitations of the Research

Despite its multidimensional design, the study faced some constraints:

Temporal scope: The two-season frame (2023–2024) provided useful insights but was insufficient to capture long-term transformations like river morphology shifts or groundwater recovery.

Data discrepancies: Official records often generalized trends, while local realities revealed more complex and spatially diverse patterns.

Remote sensing limits: Cloud cover, heavy monsoon rainfall, and resolution constraints occasionally reduced clarity of satellite imagery.

Accessibility issues: Peak inundation restricted ground verification in severely affected villages.

Subjectivity in responses: Some interviews and FGDs reflected individual biases, trauma, or political perceptions.

Even with these limitations, the integration of household surveys, FGDs, KIIs, and geospatial mapping provided robust insights. Multi-temporal satellite data (QGIS/ArcGIS) enabled spatial visualization of embankments, drainage networks, and waterlogged tracts, which were validated through field checks and community narratives. This triangulated approach exposed the gap between policy intent and local realities while strengthening the study's reliability.

Results and Analysis

Structural Measures and Their Functional Objectives

In Buxar district, structural flood management has relied on embankments, drainage channels, sluice gates, check dams, and flood shelters. These interventions were intended to reduce recurrent inundation, but their ecological and social implications differ across locations.

(a) Embankments and River Training Works

Earthen and concrete embankments along the Ganga and Karmanasha form the primary defense line. Spurs and guide bunds redirect flows and limit lateral erosion. In places such as Nainijor and Umarpur Diara, they have reduced flood exposure but also disrupted drainage and groundwater recharge.

(b) Drainage Channels and Outfall Systems

Surface channels constructed in low-lying settlements evacuate monsoon runoff into rivers and wetlands. Outfall structures regulate discharge during high flood stages, proving useful in the Chausa lowlands and near Buxar town where water stagnation previously damaged crops.

(c) Sluice Gates and Check Dams

Sluice gates prevent river backflow into drainage networks, while small check dams on tributaries like the Dharmavati regulate water levels for irrigation and dry-season needs. Their dual role in flood protection and agricultural support reflects an integrated engineering approach.

(d) Flood Shelters and Raised Platforms

In highly exposed villages, elevated shelters and platforms (uchchatak manch) serve as temporary refuge for households and livestock. Field surveys in Gangi, Gangouli, and Jawahi revealed that they remain essential for marginalized groups during peak inundation.

These structures together constitute a system of defenses designed to reduce flood risks and safeguard livelihoods. Their effectiveness, however, depends on sustained maintenance, changing hydrological dynamics, and local community involvement.

Table 4 : Major Structural Flood Control Measures and Their Functional Objectives in Buxar District

Type of Structure	Description	Location Examples	Functional Objective
Embankments	Earthen or concrete raised barriers along rivers	Along Ganga (Chausa, Brahmapur blocks)	Prevent river overflow into adjoining areas
River Training Works	Spurs, guide bunds, and bank reinforcements	Near Nainijor and Umarpur Diara	Deflect river current, reduce bank erosion
Drainage Channels	Surface channels connecting lowland areas to rivers ,	Buxar town outskirts, Chausa lowlands	Remove excess rainwater, prevent waterlogging
Sluice Gates	Gated structures to control flow between rivers and drainage canals	Karmanasha outfall region	Prevent backflow, manage discharge during floods
Check Dams	Small barriers across tributaries	Across Dharmavati and small streams	Regulate water levels, recharge groundwater
Flood Shelters & Raised Platforms	Elevated concrete/plinth shelters for human and animal refuge	Gangi, Gangouli, Jawahi	Emergency safety, reduce disaster exposure

Source: *Based on Field Survey (2023–2024)*

Socio-Economic Impacts of Structural Flood Management

Structural flood control in Buxar—embankments, drainage systems, and erosion-control works—has shaped both opportunities and challenges for local communities.

(a) Agricultural Productivity

Reclaimed land behind embankments enabled double cropping, with villages such as Nainijor and Tiwai reporting yield increases of nearly 20% in rice and wheat. Irrigation became more reliable, and flood-related crop losses declined.

(b) Residential Security and Displacement

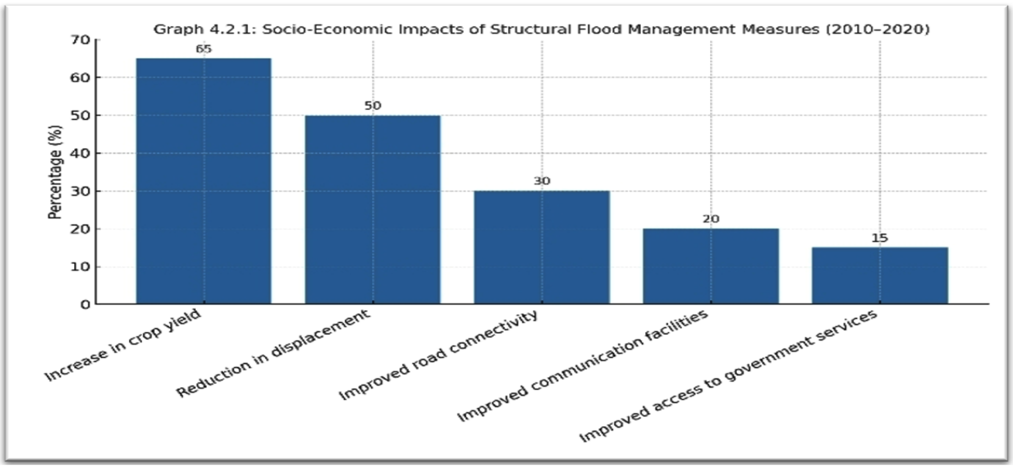
Emergency displacements fell by over one-third in Umarpur Diara and nearly half in Jawahi Diara, reflecting the protective role of embankments in safeguarding settlements.

(c) Physical Connectivity

About 52 km of embankment-associated roads improved year-round mobility. Remote villages gained quicker access to markets, schools, and health services.

(d) Administrative and Communication Access

Improved drainage and road networks strengthened disaster response and facilitated timely delivery of relief in several blocks.



Source: *Based on Field Surveys (2023–2024)*

Figure 2: Socio-Economic Impacts of Structural Flood Management Measures (2010–2020)

This chart shows household-reported improvements: agricultural productivity (65%), reduced displacement (50%), road connectivity (30%), communication access (20%), and access to government services (15%).

(e) Emerging Challenges

Benefits have not been uniform. Land acquisition for embankments displaced marginal farmers, sometimes triggering disputes. Infrastructural fragility was exposed during the 2020 Saran embankment breach, which inundated 429 villages and affected 1.46 lakh people. Traditional livelihoods—particularly boatmen and fisherfolk—declined, pushing many toward seasonal migration. Dalit households in villages such as Nainijor and Jawahi reported poor protection, delayed relief, and unequal access to safe water.

Structural measures thus provided tangible improvements in crop stability, reduced displacement, and better connectivity, yet they also reproduced vulnerabilities for marginalized groups. This duality highlights the limitations of engineering-focused approaches when equity and resilience are overlooked.

Environmental Impacts of Structural Flood Management Measures

In Buxar, interventions such as embankments, sluice gates, and drainage channels have reduced seasonal flood exposure but simultaneously disrupted the ecological balance of floodplains, altering hydrology, biodiversity, groundwater recharge, and aquatic vegetation.

Ecological Imbalance and River Flow Obstruction

Embankments and sluice structures have obstructed natural flows of distributaries like the Dharmavati, reducing wetland recharge. Gokul wetland, once a vital ecological zone, now suffers from encroachment and altered water regimes. Sedimentation has intensified riverbed aggradation, raising flood risks in adjoining habitations.

Decline in Groundwater Recharge

Structural barriers have restricted natural percolation of floodwater, lowering groundwater availability. DDMA Buxar (2022) recorded a ~50% increase in minimum depth between 2020 and 2022, highlighting reduced shallow recharge despite localized improvements.

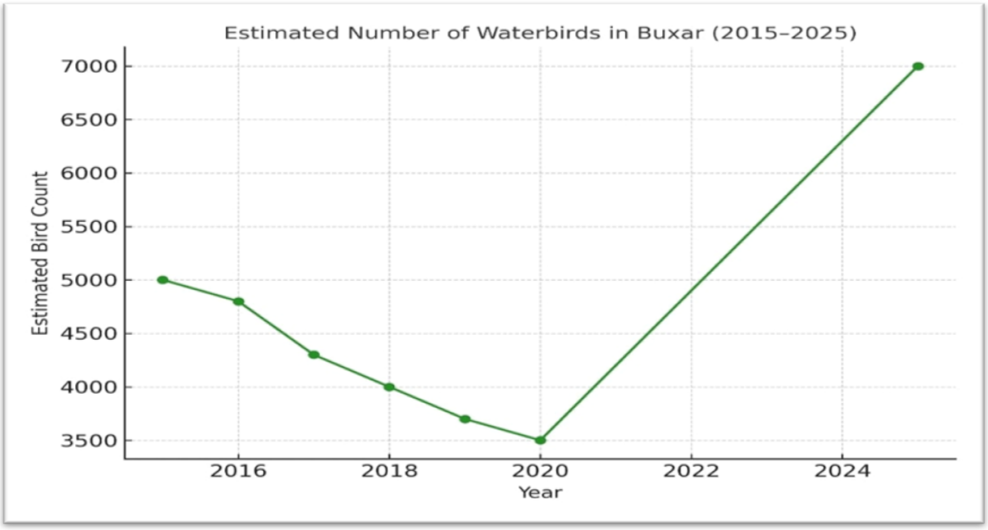
Table 4 : Groundwater Depth Statistics (2020–2022)

Year	**Minimum Depth (m)**	**Average Depth (m)**	**Maximum Depth (m)**
2020	11.3	21.3	26.9
2021	13.9	22.6	27.0
2022	16.9	22.5	25.9

Source: *DDMA Buxar (2022)*

Decline in Migratory Bird Population

Habitat loss and shrinking wetlands have reduced migratory bird numbers by nearly 30% between 2015 and 2020. Wetlands such as Gokul and Bhagar Gokhur have been overtaken by sediment or invasive weeds. Species like the Egyptian Vulture and Osprey are now rarely sighted, while the Barn Swallow population has declined below 9,500.



Source: *Compiled from Field Survey (2024), Geo24 News (2024), Times of India (2025), and Freie Universität Berlin (2023).*

Figure 3 : Estimated Population of Waterbirds in Buxar (2015–2025)

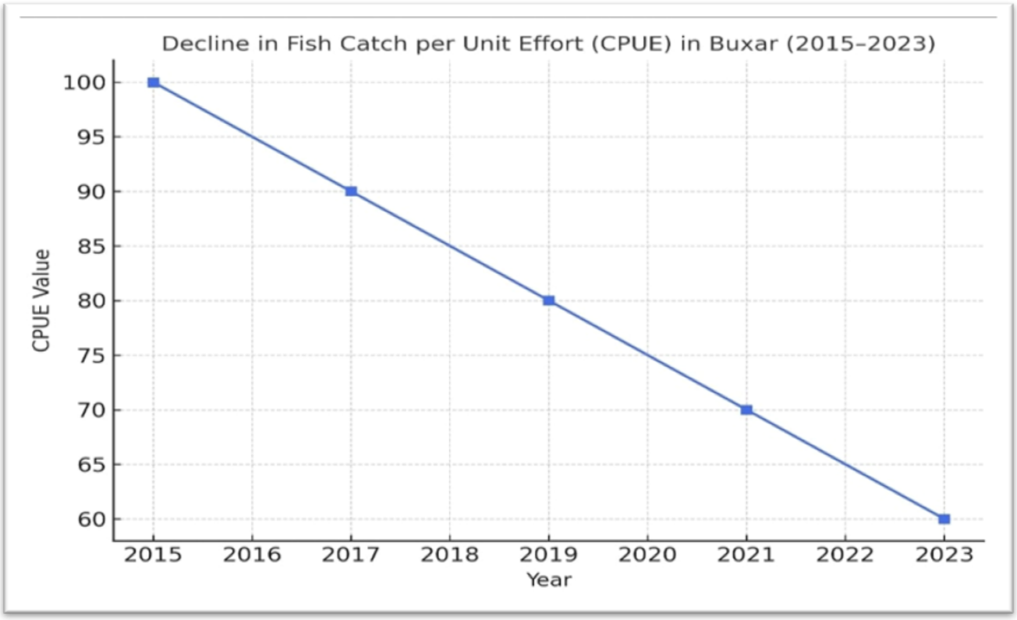
This graph illustrates observed bird population trends between 2015 and 2024, based on field surveys and ecological reports. The value for 2025 represents an early projection reported by the Times of India (2025), used here to supplement field observations.

Decline in Fish Diversity and CPUE

Changes in river morphology and aquatic obstruction have adversely affected fish habitats, particularly for traditional flood-dependent species. The Catch Per Unit Effort (CPUE) metric, which reflects fish abundance, has shown a steady decline from 2015 to 2023.

Key issues:

- Traditional fish species such as Gangetic Catla, Rohu, and Singhi have disappeared from major oxbow lakes like Bhagar Gokhur.
- Rivers such as Dharmavati, once rich in small-scale fisheries, are now disconnected from the Ganga due to embankment-induced sedimentation and blocked flow.



Source: *Compiled from Field Survey (2024), CIFRI Report (2019), DDMA Buxar (2022), and Mahapatra et al. (2021).*

Figure 4 : Decline in Fish CPUE in Buxar (2015–2023)

This graph illustrates the continuous decline in kg/day catch value.

Impact on Aquatic Vegetation and Water Quality

Drainage congestion has accelerated the spread of water hyacinth, reducing oxygen levels and degrading aquatic habitats. Infestation in oxbow lakes has lowered fish catch and worsened water-borne diseases, while villagers report unsafe water for both human and livestock use.

Overall, these findings reveal a paradox: while structural measures offer short-term protection, they have intensified long-term ecological stress through reduced groundwater recharge, wetland loss, declining biodiversity, and invasive species expansion. Complementary ecological restoration—wetland revival, weed control, and community-based conservation—is essential for balancing flood safety with ecosystem health.

Overall Effectiveness of Structural Measures

Assessing the effectiveness of flood management structures in Buxar requires consideration of three dimensions: flood control, socio-economic stability, and ecological sustainability. The evidence shows that while these interventions have provided some relief, their benefits are uneven and often temporary.

(a) Contribution to Flood Control

Embankments and engineered drainage have reduced immediate flood exposure in certain areas. In northern Chaussa block, for example, flood-affected days declined by nearly 28% between 2010 and 2020 (Field Survey 2023–24; DDMA 2022). However, their impact remains localized. In Simri and Buxar blocks, clogged drainage outlets caused waterlogging, while protective bunds redirected flows toward unprotected settlements. Thus, structural measures often shift rather than eliminate risks.

(b) Socio-Economic Security

The socio-economic gains of structural interventions are unevenly distributed. Land-owning farmers in protected zones, such as Nainijor and Tiwaya, benefited from higher yields and double-cropping. In contrast, marginal farmers and landless laborers in Jawahi Diara faced disputes and continued dependence on relief. Fishing communities reported declining catches due to obstructed river flows, forcing reliance on insecure livelihoods. These patterns reveal persistent inequality in the distribution of benefits.

(c) Ecological Balance and Sustainability

Ecological outcomes remain the weakest aspect. Groundwater recharge declined by more than 5% between 2020 and 2022, while wetlands like Gokul and Bhagar Gokhur shrank under sediment and encroachment. Fish diversity, bird populations, and aquatic vegetation have all suffered, undermining both biodiversity and local livelihoods. These ecological disruptions reinforce the paradox that measures intended to safeguard communities have simultaneously destabilized ecosystems.

Structural flood management in Buxar has delivered short-term protection and agricultural stability for some communities, but at the cost of long-term ecological decline and social inequities. Marginal farmers, fishing households, and diara residents remain particularly vulnerable. These findings emphasize the need for hybrid approaches that integrate engineering solutions with ecological restoration and participatory planning to achieve sustainable and inclusive flood resilience.

Discussion and Policy Recommendations

Building on evidence from Buxar, it is clear that while structural flood measures reduce short-term risks, they have also deepened ecological stress and social inequalities. A sustainable framework must therefore be ecologically sensitive, socially inclusive, and community-driven.

Ecological Balance-Oriented Strategies

(*a*) ***Floodplain Zoning*** – Protecting floodplains from unregulated development allows rivers to spread naturally, reducing pressure on embankments, improving recharge, and limiting waterlogging.

(b) Wetland Restoration – Reviving degraded wetlands such as Gokul Jalasay can restore biodiversity, hydrological balance, and natural flood absorption.

(c) Riparian Afforestation – Planting native vegetation along riverbanks curbs erosion, moderates flood intensity, and sustains habitats for aquatic and migratory species.

Groundwater Recharge and Water Conservation

(a) Traditional Harvesting – Community-led revival of ponds, tanks, and ahar-pyne channels strengthens local water security.

(b) Permeable Embankments – Porous structures at select sites allow controlled seepage, aiding aquifer recharge without weakening protection.

(c) Drainage Reconfiguration – Channels should be redesigned for dual use: flood mitigation and water retention, especially for irrigation and recharge.

Biodiversity Conservation and Ecological Safeguards

Flood-control structures have disturbed aquatic ecosystems, requiring corrective steps:

(a) Bird Sanctuaries – Selected wetlands along the Ganga and Karmanasha should be notified as sanctuaries to protect migratory and native birds.

(b) Restoration of Aquatic Flora – Reintroducing indigenous species like lotus, water chestnut, and makhana can stabilize wetlands and support aquatic life.

(c) Sustainable Fisheries – Organic aquaculture of native fish (Rohu, Catla, Mrigal) in oxbow lakes can revive biodiversity and traditional livelihoods.

Note**:** Invasive weeds such as water hyacinth must be systematically controlled to maintain water flow and oxygen balance.

Flood-Resilient Agriculture and Community-Based Adaptation

Agriculture must adapt to flood-prone conditions to ensure food and livelihood security:

(a) Flood-Tolerant Crops – Varieties like Swarna Sub-1 rice and short-duration pulses/vegetables reduce crop losses.

(b) Organic Soil Management – Vermicompost and green manure can restore fertility lost due to reduced silt deposition.

(c) Farm Bunding – Small earthen bunds help retain moisture, prevent erosion, and protect crops from localized flooding.

(d) Community-Based Measures – Building resilience requires village disaster committees, training in early warning systems, and IEC campaigns in local languages.

Integrated Policy Recommendations

Insights from Buxar highlight the need for policy reforms:

1. Balanced Approach – Replace purely structural models with hybrid strategies that integrate engineering, land-use planning, and ecosystem-based measures.

2. Legal Safeguards – Enforce protective zoning laws and prioritize investment in conserving floodplains and wetlands.

3. Redesign Infrastructure – Canals, embankments, and barrages should be modified to allow sediment flow, aquatic migration, and groundwater connectivity.

4. Empower Local Institutions – Equip panchayats and community groups with training and resources for participatory disaster management.

5. Climate Mainstreaming – Align flood management with long-term climate projections, addressing erratic rainfall and rising river flows.

Concluding Note

Floods are not merely natural disasters but cyclical hydrological phenomena. This study demonstrated that while structural measures in Buxar, such as embankments and drainage channels, have reduced immediate risks like displacement and crop loss, they have simultaneously created long-term vulnerabilities including waterlogging, declining groundwater recharge, and biodiversity decline. These paradoxical outcomes highlight that infrastructure alone cannot ensure resilience. The real challenge lies in society's capacity to coexist with floods through preparedness, adaptation, and ecological wisdom. For vulnerable regions such as Buxar, the future of flood resilience does not rest solely on concrete embankments but rather on the harmonious integration of people, nature, and policy.

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DIASPORIC MIGRANTS AND THEIR LOCAL INTEGRATION PERPLEXITIES: A COMPARISON OF WORLD' MOST POPULOUS WITH HIGHEST REMITTANCE RECEIVING COUNTRIES

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ABSTRACT

One of the most difficult issues facing policymakers in any nation is the integration of immigrants. Due to the sheer volume of migration, successful integration requires a determined effort. If integrated successfully, migrants can contribute to host countries in multiple ways, not least of all, economically. At the same time, integrating migrants can be difficult, particularly given that they make up highly diverse groups with a range of ages, genders, and cultural backgrounds, as well as varying skill sets, motives, and levels of education and experience. The present study makes an effort to compare the state of development of immigrant integration in the two most populous and top remittance-receiving countries of the world i.e., India and China. This study will identify the gaps between the two countries using secondary data from the Migrant Integration Policy Index (MIPEX), 2020 on several integration dimensions. It will also try to understand the gaps using a systematic literature review. The Migrant Integration Policy Index is a unique tool which measure policies to integrate migrants in countries across six continents. The index is a useful tool to evaluate and compare what government are doing to promote the integration of migrants in all the countries. It uses eight indicators such as access to nationality, anti-discrimination, education, family reunion, health, labour market mobility, permanent residence & political participation. Result reflects that family reunion and education are in favour of India. Whereas, other five indicators i.e. permanent residence, anti-discrimination, health, labour market mobility and access to nationality are in favour of China. However, the data for political participation indicator shows negligible result for both the countries. The index clearly reflects that migrants from China utilize more opportunities compared to India.

Keywords: *Immigrants; Mobility; Index; MIPEX; Policy, India, China, Remittances*

Introduction

One of the key factors impacting social and economic growth is recognized as migration, which is defined in a variety of ways. The United Nations defines migrations as "*...a move from one migration defining area to another, usually crossing administrative boundaries made*

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during a given migration interval and involving a change or residence (United Nations, 1993). It includes movement within a country as well as between countries. The process of migration has been considerably impacted by improvements in transportation and communication, as well as increased urbanization and industrialisation (Lusome and Bhagat, 2006). In today's globalized society, technology and economic opportunities have caused a flow of migrants (Sultana and Fatima, 2017). This is the cause of the global phenomena of migration in recent decades.

Indian Diaspora constitutes one of the largest in the world at 17.5 million people (United Nation, 2019 and Global migration Report, 2020). Looking at the world culture, the diaspora acts as one of the important parts of a community and country. Diaspora means spread of people to separate geographic locations from their origin either by force or by choice (Andersson, 2019). Broadly speaking, migration refers to change in place of residence; India's large diaspora is distributed across the United Arab Emirates (3.5 million), the United States of America (2.7 million) and Saudi Arabia (2.5 million) respectively. Other countries hosting large numbers of Indian migrants included Australia, Canada, Kuwait, Oman, Pakistan, Qatar and the United Kingdom. China and Russia also have spatially diffused diasporas. The Indian Diaspora that constitutes an important and unique force in some reverences spread across all six continents and 125 countries (Bhattacharya, S., & Sachdev, 2021). Over the past two centuries, India has achieved the world's most diverse migration history. The Indian diaspora is also considered as a promoter for economic development in both within India as well as in the host countries.

Meaning of Diaspora

The term "*diaspora*" originates from the Greek term disappearing, which translates as "*dispersion*". The phrase expanded over time and now broadly refers to anyone who is a citizen of a certain country and shares a common ancestry or culture but resides beyond their homeland for a variety of reasons. In India, the term "diaspora" refers to Non-Resident Indians (NRIs), Persons of Indian Origin (PIOs), and Overseas Citizens of India (OCI), the latter of which was amalgamated into a single category OCI in 2015. During British administration, vast numbers of Indians migrated as indentured labourers to former colonies such as Fiji, Kenya, and Malaysia. Dickinson & Bailey, 2007; Jain, 2012). It continued post-independence, with Indians of various social classes migrating to countries such as the United Kingdom, the United States, and Gulf countries. From Google, Microsoft, Twitter CEOs to Nobel laureate scientist Har Gobind Khorana, the list of Indians abroad and their contribution to the world goes endlessly.

Historically, “diaspora” was always concomitant with Israel and the flight of the Jews from Babylon in the fifth century, but over the past decade or so, many countries around the world have talked about their diaspora, which originated from the Greek word “dia” and “spero,” meaning over and scattering (Butler, 2001; Brinkerhoff, 2007; Gautam, 2013; Kiamba, 2014). Thus, the word “diaspora” originates from a Greek word that reflects the sense of dispersion. Movement of people also stretched the edges of the Jewish diaspora, followed by the Armenian diaspora, Chinese diaspora, African diaspora and Indian diaspora. However, these diasporas are different than Jewish diaspora, as Jewish diaspora choose one particular destination unlike other diasporas.

For instance, Indian diaspora been dispersed owing to their chosen countries of migration (Gautam, 2013). These diaspora members recognize themselves or are acknowledged by others inside and outside their homeland. While defining diaspora, Sheffer (2006) argued that modern diasporas are “ethnic minority groups of migrant origins residing and acting in host countries but maintaining strong sentimental and material links with their countries of origin-their homelands.” For the purpose of this paper, the understanding of diaspora is very similar to the definition offered by Kapur, 2010that the central idea is of communities living in one country who retain certain connections to another putative “home” country and, consequently, should not be viewed by the home country as “just another foreigner” (Kapur, 2014). Thus, it is clear that diasporas are those who disperse from an original homeland, sharing common features, culture and heritage, having a collective memory and myth about the homeland, having a sense of empathy and solidarity with co-ethnic members, developing a hybrid culture and accepting the pluralism in host countries.

Historical phases of movement of Indian Diaspora:

The Indian diaspora before becoming one the largest in the world for overseas emigration faced many phases.

1. Pre Colonial Phases
2. The colonial period phases
3. The post-colonial phases
4. Contemporary Phases

Table 1: Different phases of Movement of India Diaspora

Phase	Period & Drivers	Main Destinations	Key Features
Pre-Colonial	Ancient to early modern era	Southeast Asia, East Africa, Central Asia	Voluntary migration of traders, priests, and coastal communities; Indian cultural and religious influence spread through trade and settlement.
Colonial	19th to early 20th century	British, French, and Dutch colonies (Caribbean, Africa, Southeast Asia, Pacific)	Mass migration as indentured laborers after abolition of slavery (1833); forced/ contractual labor under indentured, Kangani, and Maistry systems; significant settlements in Mauritius, Fiji, Trinidad, Guyana, Suriname, South Africa, Malaysia, and others.
Post-Colonial	Mid-20th century (post-WWII, post-1947 Independence)	UK, USA, Canada, Australia, Gulf countries, Africa	Large-scale migration due to partition (1947), decolonization, and economic opportunities; unrestricted migration to UK (1947–1962); oil boom-driven labor migration to Gulf in 1970s; skilled professionals to Western countries.
Contemporary	Late 20th century to present	USA, Canada, UK, Australia, Gulf, Europe, Asia-Pacific	Highly skilled migration (IT, healthcare, academia); “twice migrants” (e.g., Indians from Africa to UK/Canada); globalization and economic liberalization fuelling new waves

Source: Prepared by author

The Indian diaspora has evolved through pre-colonial trade and cultural expansion, colonial-era indentured labor migration, post-colonial political and economic migration, and the contemporary movement of skilled professionals. Each phase has left a distinct mark on the global presence and character of Indian communities abroad.

Over the same period more people had a means to travel abroad in search of opportunities to work which in turn lead to India's per capita income increased by 522% (from \$1,134 to \$7,055). Due to the Indian diaspora remittance to Indian are high (Reserve Bank of India, 2025). Below gives the information how Indian diaspora led to growth of Indian economy.

Table 1: Percentage share of remittances received in India during consecutive years

Sl. No.	Year	% of remittance (\$ Billion)
1	2020	79.8
2	2021	86.3
3	2022	107.5
4	2023	110.3
5	2024	129.4

Source: *Reserve Bank of India, Monthly Report, April, 2025*

Table 1 shows the figures of recent survey on remittances published in the latest Reserve Bank of India's monthly bulletin notes that "The competitive edge and the penetration of Indian IT services overseas at the start of the century, the number of skilled emigrants to advanced economies, especially to the US, has risen significantly. Thus, besides the GCC, advanced economies have also emerged as a major source of inward remittances to India over the years". (RBI, 2025)

The fact is that the Indian community constitutes such diverse elements as South Asian Hong Kong Muslims, Canadian Sikhs, Punjabi Mexican Californians, Gujarati East Africans now settled in the U.S. by way of England, South African Hindus, and so forth. The question now is who is an Indian? How can we distinguish the Indian Diasporic community as 'Indian'? When we look at the term 'Indian Diaspora' at least in America, the Indian community has occupied a place of considerable privilege that many Indians could sidetrack the moment of recognition that 'Indianness' as opposed to 'American'. In the wake of declining economy and the separation of Indians in clusters for varied reasons has resulted for targets of racial attacks. The 'native dress' of Indian women with the vermillion dot on the forehead is easily considered as the embodiment of a otherness which has made gang of white teenagers to commit crime, who have done in New Jersey. The native Indian costume has been scrutinized and discussed in North America and the U.K in a different perspective. Sikhs in these areas have insisted that they should be exempted from the law that restricts bicyclists and motorcyclists to wear helmets, because such helmets cannot be worn on the turbans. In Californian schools Kirpan has been an issue of disputation.

However, in general the Indian communities who are settled down in any part of the globe maintain some sort of fragile link with the motherland. An Indian citizen who stays abroad as an immigrant with any kind of visa will celebrate Indian festivals /prayers and their own cultures and traditions enjoying it immensely keeping the link to the motherland. In scenarios where their children are born abroad and have never been to India, parents try and impart as much of Indian culture and traditions as they can by using our Indian parenting section. Of all the things, the most likely bonding to the Indian Diaspora is the 'Bollywood'. Bollywood movies play a crucial role in Indian diasporic communities, its success since late 1990 have brought much attention. What Hollywood is the Western Europe, the Bollywood is to the Middle East and East Africa. It is worthy to note that the Hindi films are found in the grocery and video stores in the United States. They often carry subtitles in Arabic or other language that the Indian Diaspora does not understand in the U.S. Indian 'arranged marriage' can give another dimension to the 'otherness' of the Indian Communities in the USA. The newspapers published by Indian communities will have a section for matrimonial ads. Though it helps Indians to locate their community it once again exhibits the 'otherness' in relation to 'Americans'. With the internet revolution and the media has brought about new global networking of people via Facebook, WhatsApp. messengers, tweeter. The Indian diaspora, which comprises of more than 20 million people living outside India communicate and connect with their homeland.

There are many elements that can be debatable as we start dwelling on the issues that are related to religion and religious practices of Indians. The religious faith of Indians living in India and Indian Diaspora are rather discussed with the background of religious practices that they carry out. The religious practices of Hindus, Sikhs and Muslims in the U.S and other foreign countries might have acted as a catalyst in transforming the religious faith in India itself. While pointing out the Indian Diaspora the other question that appears to the fore is the relations between parents and children, food habits and music of Indians abroad. All these diverse elements are constantly altering as the world is growing every second with new perspectives and creativity.

In 2020, there were 280.6 million (3.6 percent) global migrants which was almost quadruple the level in 1960 when migrant population was 77.1 million (2.6 percent). Thus, migrants are getting stronger in last few decades as they maintain close connections with family and friends, send remittances, and actively participating in the political, economic and cultural life of their native country. They are also playing an important role in the present social, political and economic scenario of their residing country.

Maximum migrants go to United States and Western European countries for greater economic and social stability. One of the most difficult issues facing policymakers in any nation is the integration of immigrants. Due to the sheer volume of migration, successful integration requires a determined effort. If integrated successfully, migrants can contribute to host countries in multiple ways, not least of all, economically. At the same time, integrating migrants can be difficult, particularly given that they make up highly diverse groups with a range of ages, genders, and cultural backgrounds, as well as varying skill sets, motives, and levels of education and experience. Largest numbers of migrants are from India (17.5 million), Mexico (11.8 million) and China (10.7 million). India receives maximum remittance (USD 78.6 billion), followed by China (USD 67.4 billion) and Mexico (USD 35.7 billion). The United States remained the top remittance-sending country (USD 68.0 billion) followed by the United Arab Emirates (USD 44.4 billion) and Saudi Arabia (USD 36.1 billion) in 2018.

Need for the study

India and China are two of the largest source countries for emigrants in the world, with significant numbers of people leaving each year to seek opportunities abroad. Both countries benefit from the contributions of their diaspora communities in terms of remittances, skills transfer, and cultural exchange. Secondly, India and China are indeed among the top countries in the world in terms of receiving remittances from their diaspora populations abroad. Remittances are a significant source of income for both countries and play a crucial role in their economies. Remittances are a vital source of income for millions of households in India, particularly in rural areas. This contributes to poverty reduction, household consumption, and investment in education and healthcare. Both India and China, recognize the importance of remittances and continue to explore ways to leverage diaspora resources for sustainable development. Thirdly, these two countries are experiencing remarkable economic growth the and fastest-growing major economies in the world in recent decades, and they continue to play significant roles in shaping the global economic landscape. However, their significant economic potential, large domestic markets, and growing influence in global affairs position them as key drivers of future economic growth and development. Lastly, it is crucial to note the roles of these two countries in shaping global politics, security, and economic dynamics. Their geopolitical strength is influenced by a combination of factors, including their military capabilities, economic resources, diplomatic networks, and strategic alliances.

Objectives

The present study makes an effort to compare the state of development of immigrant integration in the two most populous and top remittance-receiving countries of the world i.e., India and China.

Data &Methods:

Data Source: The present study is based on secondary Data. The Migrant Integration Policy Index was first published in 2004 as the European Civic Citizenship and Inclusion Index. It was the first time that the policies of the EU-15 towards migrants had been presented in a concise, transparent and comparable format. The 2004 Index was positively received by target audiences - NGOs, governments, academics, press and European Institutions such as the European Commission and European Parliament. It was launched in Brussels, Madrid and London. In the fifth edition (MIPEX 2020), a core set of indicators have been created that have been updated for the period 2014-2019. The index is a useful tool to evaluate and compare what governments are doing to promote the integration of migrants in all the countries analysed.

Study design and sample: The Migrant Integration Policy Index is a unique tool which measure policies to integrate migrants in countries across six continents. The index is a useful tool to evaluate and compare what governments are doing to promote the integration of migrants in all the countries. MIPEX score is based on a set of indicators covering eight policy areas that has been designed to benchmark current laws and policies against the highest standards through consultations with top scholars and institutions using and conducting comparative research in their area of expertise. The policy areas of integration covered by the MIPEX are the following: Labour market mobility; Family reunification; Education; Political participation; Permanent residence; Access to nationality; Anti-discrimination; and Health. A policy indicator is a question relating to a specific policy component of one of the 8 policy areas. For each answer, there are a set of options with associated values (from 0 to 100, e.g., 0-50-100). The maximum of 100 is awarded when policies meet the highest standards for equal treatment. Within each of the 8 policy areas, the indicator scores are averaged together to give the policy area score for each of the 8 policy areas per country which, averaged together one more time, lead to the overall scores for each country.

Data analysis: For the quantitative analysis specific Excel functions and formulas used for analysis. Use of charts and graphs in excel to visualize the trend and pattern.

Figure1: Migrant Integration Policy Index (MIPEX, 2020)

Results& Findings:

Table 1: Number of Indicators included to construct the Indices

Index	Number of Items/ Indicators
Labour Market Mobility	9
Family Reunion	16
Education	12
Political Participation	5
Permanent Residence	7
Citizenship/ Access to Nationality	8
Anti-Discrimination	10
Health	12

Source *: Migrant Integration Policy Index (MIPEX), 2020*

Among these 8 important indicators to construct indices, Family Reunion is ahead of all having 16 indicators. Next index with second highest indicators is Education and Health with 12 each followed by Anti-Discrimination, Labour Market Mobility and Citizenship as 10, 9, 8 respectively. In Political Participation Index only 5 indicators are used which is the lowest one.

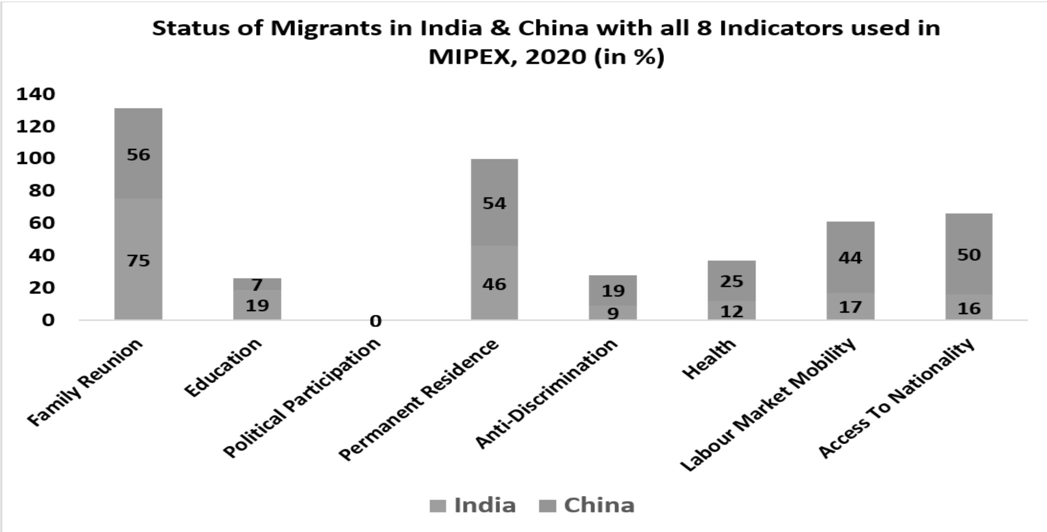

Figure 1: Status of Migrants in India & China with all 8 Indicators used in MIPEX, 2020 (in %)

Figure 1 Indicates that India's overall migrant integration policy is among the weakest, scoring poorly in most areas except family reunion, where it stands out. China's integration policies are also weak in several areas (notably education and political participation), but it generally scores higher than India in labour market mobility, health, anti-discrimination, and access to nationality. Both countries have significant room for improvement in supporting immigrant integration

Table 2: Indices used in labour market mobility in India & China

Sl. no	Indices used in Labour Market Mobility	India	China
1	Access to self -employment	100	50
2	Recognition of academic qualifications	50	100
3	Education and vocational training and study grants	0	100
4	Immediate access to labour market	0	50
5	Economic integration measures of TCNs	0	50
6	Access to social security and assistance	0	50
7	Access to public sector	0	0
8	Public employment services	0	0
9	Economic integration measures of youth and women	0	0

Source: Migrant Integration Policy Index (MIPEX), 2020

According to Labour Market Mobility Index, India is forward in only one indicator that is Access to self-employment with 100 points (refer to Table 2). China shows more balanced and broader approach, scoring in six out of nine categories e.g. Access to self-employment, Recognition of academic qualifications, vocational training and study grants, Immediate access to labour market, Economic Integration and Access to social security and assistance. In contrast, India is a head in only two indicators that is Access to Self-Employment and Recognition of academic qualifications. Moreover, both countries score zero in access to public sector, public employment services and Economic integration measures of youth and women both countries have insignificant position. China offers relatively better labour market mobility for migrants compared to India, according to MIPEX 2020.

Table 3: Indices usedin Family Reunion Indicator across India & China

Sl.no	Indices Used in Family Reunion Indicator	India	China
1	Pre-entry or immediately post-entry (i.e. in the first six months)	100	100
a.	Pre-entry or immediately post-entry (i.e. in the first six months) language form	100	100
b.	Pre-entry or immediately post-entry (i.e. in thefirst six months) integration form	100	100
2.	In-country integration requirement	100	100
a.	In-country language form	100	100
b.	In-country language level	100	100
c.	In-country integration form	100	100
3.	Requirements	100	100
4.	Economic resources	100	100
5.	Accommodation	100	100
6.	Duration of the validity of permit	100	100
7.	Residence period	100	0
8.	Grounds for rejection, withdrawal, refusal	100	0
9.	Dependent relatives	75	100
10.	Personal circumstances considered	0	0
11.	Right to autonomous residence permit for partners and children	0	0

Source: *Migrant Integration Policy Index (MIPEX), 2020*

Note: For each answer, there are a set of options with associated values (from 0 to 100, e.g., 0-50-100). The maximum of 100 is awarded when policies meet the highest standards for equal treatment.

Table 3 shows that India and China both score highly on most indices of the Family Reunion Indicator, reflecting relatively favourable policies for family reunification in terms of language, integration, economic, and accommodation requirements. India does not require a prolonged residence period, while China does. India's policies are more transparent and less discretionary than China's. China is more inclusive regarding dependent relatives than India. Neither country scores well on these aspects, indicating limited consideration for vulnerable cases and no pathway to autonomous residence for reunited family members.

Table 4: Indices used in Education across India & China

Sl. no	Education Indices	India	China
1	Language instruction standards	100	0
2	Access to higher education	50	0
3	Language instruction	28	0
4	Language instruction	50	0
5	Access to compulsoryand non -compulsory education	33	0
6	Educational guidance at all level	0	0
7	Communicative/academic fluency	0	0
8	Measures to address educational situation of migrant groups	0	50
9	School curriculum to reflect diversity	0	0
10	Diversity at school	0	0
11	Measures to bring migrants into the teacher workforce	0	50
12	Teacher training to reflect diversity	0	0
Source: Migrant Integration Policy Index (MIPEX), 2020			

Table 4 highlights that both India and China have significant gaps in their education policies for migrant integration, but China has some targeted measures for migrant groups and teacher workforce inclusion, while India does better on language standards and higher education access for migrants. Both lag behind global best practices for migrant integration in education.

Table 5: Indices used in permanent residence across India & China

Sl. no	Permanent Residence	India	China
1	Residence period	100	0
2	Language requirement	100	100
3	Duration of validity	50	100
4	Renewable permit	50	50
5	Economic resources	0	0
6	Periods of absence allowed	0	50
7	Access to social security and assistance	0	100

Source: *Migrant Integration Policy Index (MIPEX), 2020*

Table 5 reflects that India scores well on the absence of a required residence period and language requirement, but poorly on access to social security and assistance, and periods of absence allowed. China scores highly on duration of validity and access to social security and assistance, but poorly on the required residence period. Both countries do not require proof of economic resources and have only partially renewable permits.

Table 6: Indices used in citizenship across India & China

Sl. No	Citizenship Indicies	India	China
1	Naturalisation integration form	100	100
2	Economic resources	100	100
3	Naturalisation requirements	13	75
4	Naturalisation language level	50	100
5	Residence conditions for ordinary naturalisation	0	100
6	Citizenship for immigrant children (birthright and socialisation)	0	0
7	Criminal records	0	100
8	Dual Citizenship	0	0

Source: *Migrant Integration Policy Index (MIPEX), 2020*

Table 6 highlights that India's naturalisation process is much more restrictive and lengthier than China's, reflected in its low scores for naturalisation requirements and residence conditions. Both countries do not require integration tests or proof of economic resources for naturalisation, and neither allows dual citizenship or grants citizenship to immigrant children based on birthright. China scores significantly higher than India on most naturalisation indices, except for integration form and economic resources, where both score equally. This comparison clearly highlights that while both countries have some favourable aspects in their citizenship policies, China's approach is generally more accessible for migrants seeking naturalisation, whereas India's policies create substantial barriers.

Table 7: Indices used in Antidiscrimination across India & China

Sl. No	Antidiscrimination	India	China
1	Education	50	50
2	Enforcement mechanisms	25	50
3	Fields of applications	0	13
4	Law covers direct/indirect discrimination, harassment, instruction	0	0
5	Employment & vocational training	0	50
6	Social protection	0	0
7	Access to and supply of public goods and services, including housing	0	0
8	Mandate of specialised equality body	0	0
9	Equality bodies	0	0
10	Law covers positive action measures	0	0

Source: *Migrant Integration Policy Index (MIPEX), 2020*

According to Antidiscrimination Index, both India & China are at same position in terms of Education with 50 points each. While in Enforcement mechanisms and Employment and Vocational training China is in good position. In social protection, Access to and supply of public goods and services, including housing and Equality bodies neither China nor India has made any mark.

India has no comprehensive anti-discrimination law for immigrants, and policies are considered among the weakest globally. Enforcement is weak and victims of discrimination have limited recourse. Moreover, China's Anti-discrimination laws are scattered across different pieces of legislation, with no comprehensive national law. Employment law is the most developed area, with explicit prohibitions and some legal remedies, but enforcement remains inconsistent and discrimination persists, especially for migrant workers. Other areas, such as social protection and equality bodies, are not addressed in law. In this context, we can generalize that both India and China have weak anti-discrimination frameworks for migrants, but China scores higher than India in enforcement and employment protections. Neither country has comprehensive anti-discrimination laws or effective equality bodies, and both fail to address discrimination in key areas such as social protection, public goods, and positive action measures.

Table 8: Indices used in Health Indicators across India & China

Sl. No	Health Indicator Indices	India	China
1	Conditions for legal migrants	50	50
2	Administrative discretion and documentation for legal migrants	50	100
3	Conditions for asylum-seekers	50	0
4	Administrative discretion and documentation for asylum-seekers	50	0
5	Information for migrants concerning health education and promotion	33	0
6	Conditions for undocumented migrants	0	0
7	Administrative discretion and documentation for undocumented migrants	0	0
8	Information for migrants concerning entitlements and use of health services	0	0
9	Cost/availability of interpreters	0	50
10	Involvement of migrants in information provision, service design and delivery	0	0
11	Support for research on migrant health	0	50
12	Whole organisation approach	0	50
Source: Migrant Integration Policy Index (MIPEX), 2020			

Health is one of the most important factors for wellbeing of any person. Table 8 indicates that both India and China have weak health integration policies for migrants, with most indicators scoring low or zero. China scores higher than India in administrative processes for legal migrants, interpreter availability, research support, and mainstreaming of migrant health. India provides more access and information to asylum-seekers and some health education to migrants, but lacks support for research, interpreter services, or migrant involvement in health policy. Neither country addresses the needs of undocumented migrants or provides comprehensive information on health entitlements.

Conclusion

This comparative analysis of India and China two of the world's most populous countries and top recipients of remittances highlights notable differences and common challenges in how they integrate diasporic migrants. Utilizing the 2020 Migrant Integration Policy Index (MIPEX), the study examines eight key policy areas: family reunification, education, political participation, permanent residency, anti-discrimination, healthcare, labor market mobility, and nationality access.

India shows relative strength in family reunification policies, offering migrants better opportunities to reunite with their families. It also fares somewhat better in language instruction and access to higher education for migrants. However, India's overall integration framework remains restrictive in several other areas, including permanent residency, anti-discrimination protections, healthcare, labor mobility, and citizenship pathways. The naturalization process is lengthy and strict, with minimal support for migrant children or undocumented migrants, and political participation by migrants is almost non-existent.

Conversely, China surpasses India in most integration dimensions, notably in permanent residency, anti-discrimination (especially in employment), healthcare access for legal migrants, labor market mobility, and nationality acquisition. Chinese policies provide broader social security, better administrative procedures for legal migrants, and enhanced support for health research and interpreter services. Nevertheless, China faces significant gaps in migrant education particularly in support for migrant children political participation, and the absence of birthright citizenship for migrant children.

Both nations share weaknesses such as inadequate anti-discrimination laws, limited aid for undocumented migrants, and a lack of comprehensive efforts to encourage diversity and migrant engagement in public sectors. Neither country permits dual citizenship or grants substantial political rights to migrants. Overall, MIPEX indicates that migrants in China have access to more integration opportunities than those in India. Yet, both fall short of global best practices and have considerable scope for improvement to establish inclusive, rights-based systems that foster migrants' social, economic, and civic integration.

As India and China continue to influence global migration and remittance trends, enhancing their integration policies is vital not only for migrants' welfare but also for social cohesion and economic growth in both countries. Policymakers should focus on reforming anti-discrimination measures, education, healthcare, and citizenship pathways while promoting greater migrant participation and representation in public life. Such advances will help ensure that migration remains a catalyst for development, innovation, and intercultural exchange in the coming decades.

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MAPPING THE EDUCATIONAL LANDSCAPE: AN ASSESSMENT OF THE PROSPECTS OF ACHIEVING SUSTAINABLE DEVELOPMENT GOAL (SDG) 4 IN INDIA

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ABSTRACT

Sustainable Development Goal 4 (SDG 4) aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030. This study evaluates India's progress toward achieving SDG 4 by analyzing key educational indicators, including completion rates, out-of-school rates, government spending, teacher qualifications, and access to educational infrastructure. Data from the United Nations' SDG indicators database and India's National Achievement Survey are analyzed using the Holt-Winters time series forecasting method to project trends up to 2030. The findings indicate significant progress in primary education, with near-universal completion rates projected, but challenges persist in upper secondary education, where completion rates fall short of targets. Regional disparities are acknowledged, though detailed state-level data is limited. The study highlights the need for targeted interventions to enhance educational infrastructure, increase teacher training, and address regional inequities to ensure India meets all SDG 4 targets by 2030.

Keywords: *Education, India, Regional Disparities, Sustainable Development Goal 4, Time Series Forecasting*

Introduction

Sustainable Development Goal 4 (SDG 4), adopted by the United Nations in 2015, aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030. Education plays a central role in reducing poverty, improving health, fostering gender equality, and driving economic growth. In India—a country of over 1.3 billion people with vast cultural and socio-economic diversity—achieving SDG 4 is both an urgent priority and a complex challenge.

India has expanded access to primary education, reaching a gross enrollment ratio of 97.2% in 2018. However, high dropout rates, particularly at the secondary level (only 58.5% completed

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upper secondary in 2020), inadequate infrastructure, and regional disparities remain critical issues. States like Kerala lead with literacy rates above 90%, while others like Bihar and Uttar Pradesh lag below 70%. Marginalized groups, especially rural girls, face barriers such as poverty, early marriage, and inadequate school facilities.

The COVID-19 pandemic further deepened these challenges, affecting over 320 million learners and exposing a severe digital divide. While urban areas adapted to online education, many rural students lacked access to digital tools and connectivity. Additionally, disparities in teacher qualifications and learning outcomes persist across regions. This study evaluates India's progress toward SDG 4 using data from the UN SDG Indicators Database and the National Achievement Survey, applying the Holt-Winters forecasting method to project trends up to 2030. It also highlights regional disparities and identifies areas needing urgent policy attention. The objectives are threefold: to assess current educational indicators, analyze regional variations, and project future progress toward SDG 4.

India's success in achieving SDG 4 has global relevance. As a leading developing country, its strategies and challenges offer valuable lessons for others. By identifying gaps in infrastructure, quality, and equity, this study provides evidence-based insights for shaping more inclusive educational policies and accelerating sustainable development.

Literature Review

The pursuit of Sustainable Development Goal 4 (SDG 4) in India—ensuring inclusive and equitable quality education—has drawn extensive scholarly attention. Research highlights considerable progress in primary education enrollment alongside persistent challenges in quality, access, equity, infrastructure, and regional disparities.

According to Tilak (2018), near-universal primary enrollment was achieved by 2015, largely due to the Right to Education Act (2009). However, Kingdon (2020) and UNESCO (2020) point to significant dropouts at the secondary level, with upper secondary completion at just 58.5% in 2020. Socio-economic barriers continue to hinder progress for vulnerable populations.

Quality of education remains a core issue. The National Achievement Survey (NCERT, 2021) reported a decline in Class VIII learning outcomes. Muralidharan (2019) and Banerji (2022) attribute this to outdated pedagogies and rote learning that suppress analytical and creative skills. Gender equity has improved, with the Gender Parity Index (GPI) for upper secondary education reaching 0.9 by 2020 (Dreze and Sen, 2019). Still, barriers such as early marriage, poor sanitation, and patriarchal norms persist, especially in rural areas (Kabeer, 2021; Azam and Kingdon, 2013), notably in Uttar Pradesh and Bihar.

Digital infrastructure poses another challenge. Kundu (2020) found that only 5.2% of primary schools had internet access in 2017, a weakness exacerbated by the COVID-19 pandemic. UNESCO (2020) noted disruption to 320 million students, with rural learners most affected. Mukhopadhyay (2023) emphasized the digital divide as a major threat to SDG 4's inclusiveness.

Teacher qualifications remain uneven. While Jha (2022) reported that 94% of primary teachers were qualified by 2023, Varghese (2019) criticized teacher training, and Kumar and Sikka (2021) highlighted state-level disparities—Bihar lags far behind states like Kerala. Regional inequality is central to India's SDG 4 landscape. Kundu and Rao (2017) show a stark contrast between Kerala's 93.9% and Bihar's 61.8% literacy. Kare et al. (2016) observed that urban growth, such as in Pune, can create new educational inequalities. Sharma (2020) draws attention to chronic rural infrastructure deficits in northern India.

In terms of policy and funding, Mehrotra (2018) notes that India's education expenditure (4.4% of GDP) remains below the recommended 6%. While the National Education Policy (2020) seeks to improve quality, Jha and Parvati (2021) argue that resource constraints hamper its execution. Sen (2023) highlights increased international scholarship support but underlines the need for stronger domestic financing. The COVID-19 pandemic worsened educational inequalities. Alvi and Gupta (2021) estimated learning losses equivalent to one academic year, especially in foundational skills, a trend echoed by UNESCO (2020).

Together, these studies show that while India has achieved notable gains in access and gender parity, it still faces critical obstacles in learning outcomes, retention, infrastructure, and equity. This study builds on the existing literature by applying the Holt-Winters time series model to forecast India's progress toward SDG 4—a data-driven approach not widely used in previous research.

Objectives

1. Evaluate the current status of educational indicators in India with respect to SDG 4.
2. Identify regional disparities in educational development across India.
3. Project future scenarios for achieving SDG 4 using time series forecasting.

Methodology

This study employs a quantitative approach, utilizing data from the United Nations' SDG indicators database (United Nations) and India's National Achievement Survey (NAS). The Holt-Winters forecasting method, suitable for time series data with trends and seasonality, is used to project educational indicators to 2030. The Holt-Winters method is a time series forecasting technique used when the data exhibit both trend and seasonality. It is an extension of exponential smoothing and works by updating estimates of:

1. **Level (L_t):** The baseline or average value of the series at time *t*.
2. **Trend (T_t):** The slope or rate of change (increase or decrease) over time.
3. **Seasonality (S_t):** The recurring fluctuations over a fixed seasonal period (e.g., yearly, quarterly).

These components are combined to make future forecasts.

Two Versions of the Model

1. **Additive Model** (used when seasonal effects are constant, i.e., they do not grow/shrink with the trend):

$$Y_{t+m} = (L_t + m * T_t) + S_{t+m}$$

2. **Multiplicative Model** (used when seasonal effects increase or decrease proportionally with the trend):

$$Y_{t+m} = (L_t + m * T_t) \ S_{t+m}$$

Model Components Explained

- **Level (L_t):** A smoothed estimate of the average at time *t*, accounting for trend and seasonality.
- **Trend (T_t):** The estimated increase or decrease per time step (e.g., per year).
- **Seasonality (S_t):** A periodic factor that captures seasonal ups and downs.
- **Forecast (Y_{t+m}):** The predicted value *m* periods into the future, combining all three components.

The forecast horizon *m* determines how far ahead the forecast goes (e.g., predicting educational indicators for 2030 from 2023 data).

The Holt-Winters Multiplicative Model was selected for this study due to the seasonal and irregular fluctuations in education indicators caused by the COVID-19 pandemic. Variables such as enrollment, learning outcomes, digital access, and government spending showed recurring disruptions during each wave of the pandemic, with varying intensity over time. Unlike simpler models, Holt-Winters effectively captures both trend and time-varying seasonal components, making it ideal for forecasting under such instability. This model enabled more accurate projections of India's progress toward SDG 4 targets by 2030, particularly in areas like school completion rates, infrastructure development, and teacher qualifications.

Data Source: This study uses secondary data from credible national and international sources. Key data were drawn from UDISE+ reports and education budgets (Ministry of Education), NAS reports (NCERT) for learning outcomes, and NITI Aayog's SDG India Index for national and state-level progress. Global indicators were sourced from UNESCO's UIS database, while historical trends were supported by the Census of India (2011) and National Sample Survey data on literacy, enrollment, and access..

Discussion: This section presents a detailed analysis of India's progress toward achieving Sustainable Development Goal 4 (SDG 4) by 2030, with a focus on each target outlined under the SDG 4 framework. Using data from national and international sources, the study applies the Holt-Winters Multiplicative Model to project future trends and account for the seasonal and irregular disruptions caused by the COVID-19 pandemic. The discussion is structured target-wise, evaluating India's current status, identifying gaps, and forecasting progress across key indicators such as enrollment, completion rates, infrastructure, gender parity, literacy, teacher qualifications, and scholarship access.

Target 1.a – Mobilization of Resources for Essential Services: Adequate and sustained funding is essential for improving India's education system, especially to enhance infrastructure, ensure teacher availability, and support marginalized communities. Investment is also vital to recover from COVID-19-related learning losses. Target 1.a of the SDGs focuses on mobilizing resources to support development policies, with Indicator 1.a.2 tracking the share of government spending on essential services like education, health, and social protection.

Table 1: The proportion of government spending on education and its share of GDP are critical for SDG 4.

Year	Proportion of Total Spending (%)	Expenditure as % of GDP
2018	13.1	4.4
2020	15.0	4.0
2023	14.2	4.34
2030 (Predicted)	15.59	4.59
Target (2030)	**15–30**	**4–6**

Source: *United Nations SDG Indicators Database.*

According to Table 1, India's spending on education as a proportion of total government expenditure increased from 13.1% in 2018 to 14.2% in 2023, and is projected to reach 15.59% by 2030, meeting the lower threshold of the target range (15–30%). Similarly, education expenditure as a percentage of GDP stood at 4.34% in 2023, and is forecasted to rise modestly to 4.59% by 2030, within the target range of 4–6%, though still significantly below the recommended 6% benchmark suggested by the Kothari Commission and reiterated in India's National Education Policy (2020). The Holt-Winters multiplicative forecasting model was used to project these values, accounting for seasonal variations and irregularities—especially those induced by the COVID-19 pandemic. Although the projections indicate alignment with minimum targets, the limited rate of growth in public education expenditure suggests the need for greater fiscal prioritization and policy commitment to ensure long-term gains under SDG 4.

Target 4.1 – Completion of Primary and Secondary Education: In India, completing primary and secondary education is crucial for reducing poverty, empowering youth, and addressing inequality. Target 4.1 of the SDGs aims to ensure all children complete free, equitable, and quality education by 2030. While India has achieved near-universal enrollment at the primary level, dropout rates remain high at the secondary level, especially among girls, rural, and marginalized groups. Despite progress, ensuring school completion remains a key challenge. The COVID-19 pandemic further disrupted learning, underscoring the need for targeted interventions and accurate projections to guide policy and close remaining gaps.

Table 2: Completion Rates (%)

Level of Education	2015	2020	2024	2030 (Predicted)	Target (2030)
Primary	90.8	94.3	96.2	100	100
Upper Primary	80.6	86.5	89.9	95	100
Upper Secondary	49.4	58.5	64.0	72.25	88

Source: *United Nations SDG Indicators Database*

According to the UN SDG Indicators Database, India's primary education system is on track to achieve universal completion by 2030, with completion rates rising from 90.8% (2015) to 96.2% (2024) and out-of-school rates falling from 9% to 3%, projected to reach 0% by 2030. This reflects the impact of initiatives like the Right to Education Act, Mid-Day Meal Scheme, and Samagra Shiksha Abhiyan. At the upper primary level, completion has improved to 89.9% in 2024, with a projection of 95% by 2030—close but still below the 100% target. Barriers persist for marginalized groups due to poverty, poor infrastructure, and gender inequality. Progress in upper secondary education is most concerning. Completion rose modestly from 49.4% (2015) to 64.0% (2024), and is projected to reach just 72.25% by 2030—well below the 88% target. The out-of-school rate remains alarmingly high at 39%, reflecting deep-rooted challenges like economic hardship, early marriage, and lack of support for adolescent learners.

Table 3: Out-of-School Rates (%)

Level	2015	2020	2024	2030 (Predicted)	Target (2030)
Primary	9	6	3	0	0
Upper Primary	13	12	9	6	0
Upper Secondary	42	41	40	39	12

Source: *United Nations SDG Indicators Database*

Reducing out-of-school rates is a core aspect of SDG Target 4.1, which aims to ensure universal completion of primary and secondary education. In India, significant progress has been made at the primary level (Table 3), where the out-of-school rate declined from 9% in 2015 to 3% in 2024, and is expected to reach 0% by 2030, fully meeting the target. At the upper primary level, the rate has decreased from 13% to 9%, and is projected to fall to 6% by 2030, though still short of the target. However, upper secondary education remains a major challenge. Out-of-school rates have remained largely stagnant, from 42% in 2015 to an estimated 39% by 2030, far above the target of 12%. This highlights persistent barriers such as economic hardship, inadequate school infrastructure, and gender-based constraints, which require urgent and focused policy attention to improve secondary education retention..

Target 4.2 – Access to Early Childhood Education: Early childhood education is crucial for laying the foundation for cognitive, emotional, and social development in children. In India, where millions of children enter formal schooling without prior exposure to structured learning, ensuring access to quality pre-primary education is essential for school readiness, reducing dropout rates, and improving long-term learning outcomes. It is particularly significant for children from disadvantaged backgrounds, where early stimulation and educational exposure are often limited. Target 4.2 defined as "*By 2030, ensure that all girls and boys have access to quality early childhood development, care, and pre-primary education so that they are ready for primary education*".

Table 4: Adjusted net enrolment rate, one year before the official primary entry age, both sexes (%)

Year	Rate (%)
2015	85.5
2020	88.7
2024	94.4
2030 (Predicted)	100
Target (2030)	100

Source: *United Nations SDG Indicators Database*

India has made notable progress in expanding access to early childhood education (Table 4). The Adjusted Net Enrolment Rate (ANER) in pre-primary education increased from 85.5% in 2015 to 94.4% in 2024, showing steady growth. According to projections, this rate is expected to reach 100% by 2030, thereby fully achieving the SDG 4.2 target. This progress reflects the integration of early childhood care into mainstream policy frameworks, such as the Samagra Shiksha Abhiyan, the National Education Policy (2020), and the strengthening of Anganwadi centers under the Integrated Child Development Services (ICDS). The upward trend also demonstrates growing public awareness of the importance of early learning and government efforts to make pre-primary education more accessible, especially in rural and underprivileged areas. The projected 100% enrolment rate suggests India is on track for this target, reflecting strong progress in early education access.

Target 4.3 – Equal Access to Tertiary and Vocational Education: Access to higher and vocational education is vital for developing a skilled, productive, and globally competitive workforce in India. As the country moves toward a knowledge-based economy, ensuring inclusive and equitable access to tertiary education becomes essential for reducing socio-economic inequalities and empowering youth, particularly from marginalized communities. In India, expanding vocational training and improving participation in post-secondary education also help address the challenges of unemployment and underemployment among the youth. This target says that "By 2030, ensure equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university."

Table 5: Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, both sexes (%)

Year	Rate (%)
2015	85.5
2020	88.7
2024	94.4
2030 (Predicted)	100
Target (2030)	100

Source: *United Nations SDG Indicators Database*

India has shown consistent improvement in participation in both formal and non-formal education at the tertiary level (Table 5). The participation rate increased from 85.5% in 2015 to 94.4% in 2024, and is projected to reach 100% by 2030, thus fully meeting the SDG 4.3 target. This growth reflects the impact of various national initiatives, such as the Rashtriya Uchchatar Shiksha Abhiyan (RUSA), the National Apprenticeship Promotion Scheme (NAPS), and the Skill India Mission, which have collectively enhanced access to college education, technical training, and vocational skill development. The expansion of open and distance learning platforms, online certification programs, and the increasing role of public-private partnerships in education delivery have also contributed to the upward trend. Nevertheless, to maintain this momentum and ensure quality alongside access, continued investment in infrastructure, curriculum modernization, and equitable access for women and socio-economically disadvantaged groups remains critical.

Target 4.4 – Skills for Employment and Entrepreneurship: In India's technology-driven economy, equipping youth with relevant skills is vital to harness its demographic dividend and reduce unemployment. Target 4.4 aims to substantially increase the number of youth and adults with technical and vocational skills by 2030. India has launched key initiatives like PMKVY, Skill India, and DDU-GKY to promote industry-aligned training. While these programs have expanded skill development, access remains uneven, particularly among rural youth, women, and school dropouts. Bridging this gap is essential for inclusive growth, employability, and social mobility.

Table 6 : estimated and projected percentage of youth (aged 15–24) and adults (aged 25–45) with formal vocational or technical training in India

Year	Youth (15–24)	Adults (25–45)
2015	5.4%	4.0%
2020	8.6%	6.2%
2024	12.3%	9.1%
2030 (Predicted)	25.0%	18.0%
Target (2030)	Substantial increase (estimated ~25–30%)	Substantial increase

Source: *Ministry of Skill Development and Entrepreneurship (MSDE), NSDC Reports, and United Nations SDG Indicators Database*

While the participation rate in skill training is gradually increasing, projections indicate that India may reach around 25% of youth and 18% of adults with vocational or technical skills by 2030 (Table 6). Although this marks significant progress compared to the 2015 baseline, it still suggests that India must accelerate efforts to universalize skill training access, particularly in Tier II/III towns and rural belts. Key challenges include low awareness, mismatch between skills taught and job market needs, lack of qualified trainers, and inadequate training infrastructure in many regions.

Target 4.5 – Gender Parity in Education: Eliminating gender disparities in education is crucial for achieving social equity and sustainable development, particularly in a country like India where socio-cultural norms, poverty, and regional imbalances often restrict girls' educational opportunities beyond the primary level. Target 4.5 of the Sustainable Development Goals focuses on eliminating gender disparities in education and ensuring equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in disadvantaged situations. In the Indian context, promoting gender parity is essential not just for women's empowerment but also for improving household health, child education, and economic outcomes at the community level.

Table 7: Upper Secondary Completion Rate Gender Parity Index

Year	Gender Parity Index
2017	0.9
2020	0.9
2023	0.9
2030 (Predicted)	1.0
Target (2030)	1.0

Source: *United Nations SDG Indicators Database*

India has made steady progress toward this goal (Table 7). The Gender Parity Index (GPI) for upper secondary school completion has remained consistent at 0.9 from 2017 to 2023, reflecting near parity between boys and girls. According to projections, the GPI is expected to reach 1.0 by 2030, thus fully meeting the SDG target. This improvement has been supported by a range of national initiatives such as Beti Bachao Beti Padhao, Kasturba Gandhi Balika Vidyalaya, free bicycles and uniforms for girls, and the construction of girls' toilets in schools, all of which have contributed to improving girls' enrollment and retention, particularly in rural and underserved areas. While the trajectory toward parity is promising, maintaining this momentum will require sustained attention to addressing regional disparities, curbing early marriage, improving school safety, and enhancing access to digital learning—especially in the post-pandemic period. Without continued investment in gender-sensitive education policies, progress may stagnate or even reverse in some : Literacy and numeracy are foundational skills essential for lifelong learning, regions.

Target 4.6 – Literacy and Numeracy Proficiency : Literacy and numeracy are foundational skills essential for lifelong learning, personal empowerment, and socio-economic development. In India, where many children—especially in rural and disadvantaged areas—struggle with basic reading and arithmetic skills even after several years of schooling, improving proficiency in these core areas is a national priority. Target 4.6 of the Sustainable Development Goals aims to ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy proficiency by 2030. Achieving this target is crucial to address learning poverty, reduce dropout rates, and enhance the effectiveness of public education systems.

Table 8: Average Student Performance in Language and Mathematics

Level	Language (2017)	Language (2021)	Language (2030)	Mathematics (2017)	Mathematics (2021)	Mathematics (2030)
Class III	336	323	360	321	306	340
Class V	319	309	330	310	284	320
Class VIII	307	302	315	269	255	280

Source: *National Achievement Survey*

Despite growing efforts, India's progress in this area remains modest. As per the National Achievement Survey (NAS) data (Table 8), student performance in both language and mathematics has declined slightly between 2017 and 2021, and the projected improvements by 2030 are relatively small. For instance, the average language score for Class III dropped from 336 in 2017 to 323 in 2021, and is expected to rise to 360 by 2030. Similarly, the mathematics score for the same class declined from 321 to 306, with a projection of 340 by 2030. Class V students are expected to show slight improvement as well, with language scores increasing from 309 to 330, and math scores from 284 to 320. In Class VIII, the performance remains concerning, with only minor projected increases—from 302 to 315 in language, and 255 to 280 in mathematics. These projections, though positive, indicate only incremental gains, suggesting that India must strengthen foundational literacy and numeracy through targeted interventions such as the NIPUN Bharat Mission, improved teacher training, remedial programs, and revised curriculum and pedagogy that prioritize understanding over rote memorization.

Target 4.a – Educational Infrastructure

Access to safe, inclusive, and technology-enabled educational environments is a cornerstone of quality education in the 21st century. In India, ensuring that schools are equipped with basic infrastructure such as electricity, computers, internet connectivity, and sanitation facilities is crucial—especially in rural and government schools—to bridge the digital divide and support modern learning practices. Target 4.a of the Sustainable Development Goals seeks to build and upgrade education facilities that are child-, disability-, and gender-sensitive, and that provide safe, inclusive, and effective learning environments for all. In today's digital era, access to computers and internet connectivity is fundamental for equitable learning and technology integration in classrooms.

Table 9: Proportion of Schools with Computer Access (%)

Level	2017	2020	2023	2030 (Predicted)
Primary	10.2	18.9	29.8	52.87
Lower Secondary	36.3	43.1	51.5	73.7
Secondary	48.1	58.6	66.2	94.5
Upper Secondary	68.1	77.7	87.8	100

Source: *United Nations SDG Indicators Database*

India has made progress in this direction, but the growth remains uneven across educational levels. As shown in Table 9, the proportion of primary schools with computer access has increased from 10.2% in 2017 to 29.8% in 2023, and is projected to reach 52.87% by 2030. In contrast, upper secondary schools are expected to achieve 100% computer access by 2030, reflecting a clear infrastructural gap between lower and higher levels of education. Similarly, lower secondary and secondary schools are projected to reach 73.7% and 94.5% computer access respectively by 2030.

Table 10: Proportion of Schools with Internet Access (%)

Level	2017	2020	2023	2030 (Predicted)
Primary	5.2	7.9	28.9	48.7
Lower Secondary	17.3	24.2	50.4	64.9
Secondary	32.2	39.3	60.4	82.6
Upper Secondary	46.8	58.5	75.5	97.7

Source: *United Nations SDG Indicators Database*

A similar trend is evident in Table 10, which presents the proportion of schools with internet access. Primary schools show limited progress, with access increasing from just 5.2% in 2017 to 28.9% in 2023, and projected to reach only 48.7% by 2030. In contrast, upper secondary schools are projected to reach 97.7% internet coverage, and secondary schools 82.6% by 2030. While this indicates substantial progress at higher levels of education, it also highlights persistent disparities that may widen the digital divide—especially for young learners in rural and under-resourced areas.

While India is progressing steadily in expanding computer and internet access in schools, the benefits remain unequally distributed. Upper secondary schools are nearing full digital readiness, but primary and lower secondary schools lag behind, especially in rural and underfunded areas. Bridging this gap is essential to fulfill the vision of Target 4.a, ensuring that all students—regardless of location or background—have access to safe, inclusive, and technologically equipped learning environments.

Target 4.b – Scholarships for Higher Education: Expanding access to higher education through financial assistance is essential for promoting equity and inclusive growth, especially in developing countries like India, where economic barriers often prevent students from marginalized communities from pursuing tertiary education. Target 4.b of the Sustainable Development Goals aims to substantially expand globally the number of scholarships available to developing countries, particularly for enrolment in higher education, including vocational training and information and communications technology, technical, engineering, and scientific programs.

India has witnessed significant growth in external support through scholarships over recent years. As shown in Table 11, the Official Development Assistance (ODA) for scholarships increased from USD 16.6 million in 2017 to USD 67.9 million in 2023, and is projected to reach USD 80.06 million by 2030. This upward trend reflects increasing global cooperation and support for India's education sector, facilitating more opportunities for Indian students to study abroad or access international-standard higher education within the country.

Table 11: Official Development Assistance for Scholarships (USD millions)

Year	Assistance
2017	16.6
2020	28.5
2023	67.9
2030 (Predicted)	80.06

Source: *United Nations SDG Indicators Database*

While the projected increase in scholarship aid is promising, ensuring equitable distribution and awareness of these opportunities remains a challenge. Continued focus on outreach, transparency in allocation, and support for underrepresented groups will be essential to fully realize the impact of these scholarships in advancing SDG 4.

Target 4.c – Qualified Teachers: Qualified teachers play a pivotal role in delivering quality education, improving learning outcomes, and supporting student retention. In India, teacher availability and qualification levels are particularly important due to vast regional disparities and the presence of a large number of government and low-fee private schools, especially in rural areas. Target 4.c of the Sustainable Development Goals calls for substantially increasing the supply of qualified teachers, including through international cooperation for teacher training in developing countries, to ensure inclusive and equitable quality education for all.

Table 12: Proportion of Teachers with Minimum Qualifications (%)

Level	2017	2020	2023	2030 (Predicted)
Pre-Primary	80.2	83.3	93.0	100
Primary	69.8	77.7	94.9	100
Lower Secondary	76.6	78.9	91.6	95.26
Secondary	76.5	80.2	92.0	95.83
Upper Secondary	76.4	81.7	92.4	98.91

Source: *United Nations SDG Indicators Database*

India has made remarkable progress in enhancing teacher qualifications across all education levels. As shown in Table 12, the proportion of teachers meeting the minimum qualification standards has risen significantly. In pre-primary education, qualified teachers increased from 80.2% in 2017 to 93.0% in 2023, and are projected to reach 100% by 2030. Similarly, primary education shows steady improvement from 69.8% in 2017 to 94.9% in 2023, also expected to reach 100% by 2030.

At the lower secondary level, teacher qualification improved from 76.6% to 91.6% during 2017–2023, and is projected to reach 95.26% by 2030. For secondary and upper secondary levels, the rates were 92.0% and 92.4% respectively in 2023, with projected increases to 95.83% and 98.91% by 2030. These figures suggest that while India is on track to meet or approach full qualification at all levels, continued investment in teacher training infrastructure and pedagogical upskilling is necessary to meet emerging needs, especially in STEM and digital education. India is steadily moving toward achieving full teacher qualification across all school levels. However, bridging the remaining gaps—particularly in secondary education—requires focused policy action on quality teacher education, equitable deployment, and continuous professional development to ensure that every child receives instruction from a qualified and competent teacher.

Regional Disparities: Regional disparity is pivotal in assessing India's progress toward SDG 4 due to the country's heterogeneous socioeconomic, cultural, and geographic landscape. Differences in economic development, urbanization, infrastructure availability, and cultural norms significantly influence educational outcomes across regions. The 2030 predictions for India's progress toward Sustainable Development Goal 4 (SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) are analyzed based on six indicators:

- **Target 4.1:** Adjusted Net Enrolment Rate (ANER) in elementary education (classes 1-8, target: 100%).
- **Target 4.3:** Gross Enrolment Ratio (GER) in higher education (ages 18-23, target: ≥50%).

- **Target 4.5:** Gender Parity Index (GPI) for higher education (ages 18-23, target: ≥1, indicating equal or higher female enrollment relative to males).
- **Target 4.6:** Percentage of students in grade VIII achieving at least a minimum proficiency level in terms of nationally defined learning outcomes (target: 100%).
- **Target 4.a:** Percentage of schools with access to basic infrastructure (electricity and drinking water, target: 100%).
- **Target 4.c:** Percentage of trained teachers at secondary level (classes 9-10, target: 100%).

Targets 4.2 (early childhood development), 4.4 (skills for employment), and 4.b (scholarships) are excluded due to the unavailability of state-wise data.

Table 13 presents the predicted values of selected DG4 Targets for the year 2030. The 2030 predictions are based on 2021 and 2024 data. To mitigate the adverse effects of COVID-19 disruptions (e.g., enrollment declines due to school closures and economic pressures), negative GPI trends from 2021 to 2024 were reversed to positive (annual change = |(GPI 2024 - GPI 2021) / 3|, then GPI 2030 = GPI 2024 + (absolute change × 6)), assuming recovery through interventions like scholarships and re-enrollment campaigns. Positive GPI trends were retained. Other indicators (ANER, GER, Proficiency, Infrastructure, Trained Teachers) were similarly adjusted to reflect post-COVID recovery.

States are categorized based on the number of targets met out of 6 (ANER=100, GER≥50, GPI≥1, Proficiency=100, Infrastructure=100, Trained=100):

- **States Achieving Full Compliance with All SDG 4 Targets:** Meet all 6 targets.
- **States Demonstrating Substantial Compliance with Four or More SDG 4 Targets:** Meet 4 or 5 targets.
- **States Exhibiting Limited Compliance with Fewer Than Four SDG 4 Targets:** Meet fewer than 4 targets.

This categorization reflects the degree of progress toward SDG 4, with "Substantial Compliance" encompassing states close to full achievement, requiring fewer interventions than those with "Limited Compliance."

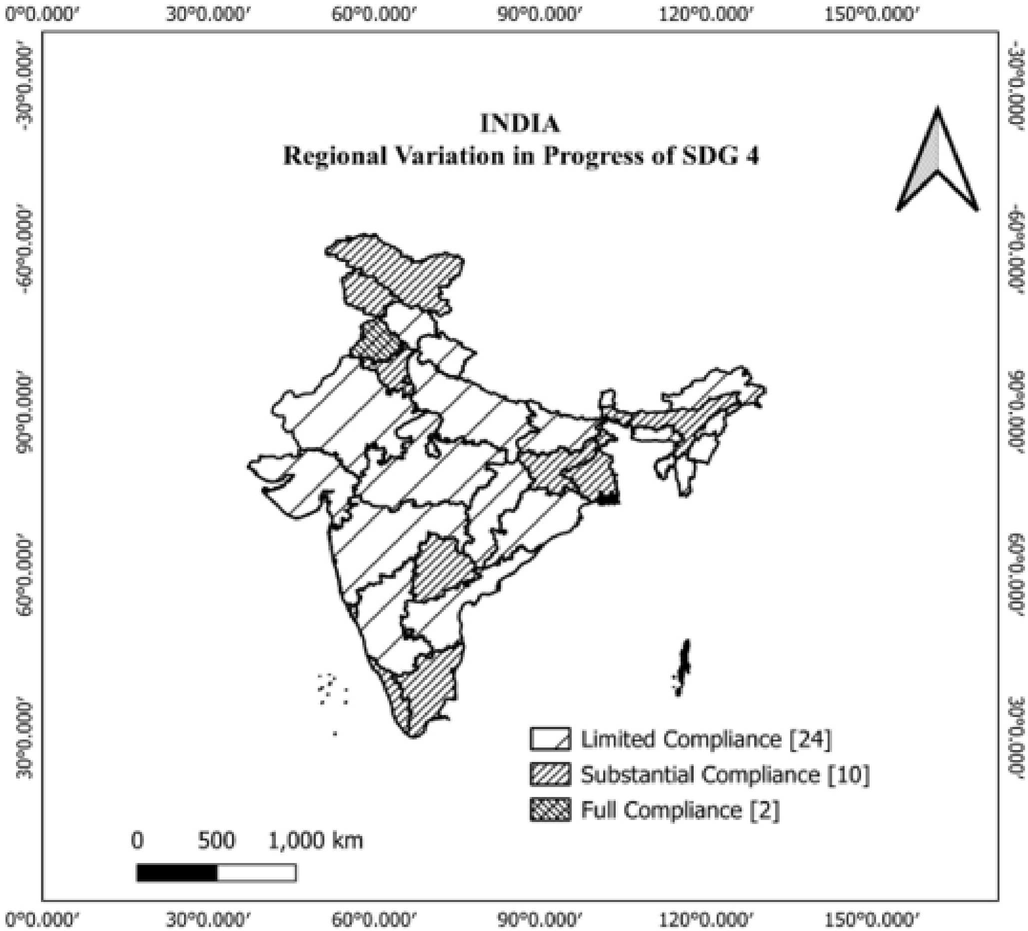
Northern Region: The northern states demonstrate strong performance in access-related targets, with both the Adjusted Net Enrolment Rate (Target 4.1) and school infrastructure coverage (Target 4.a) close to or at 100%, and most states achieving full compliance on trained secondary-level teachers (Target 4.c). Higher education participation (Target 4.3) is particularly impressive in Delhi (100%), Punjab (65.4%), Himachal Pradesh (70.9%), and Uttarakhand (73.8%), indicating a dense network of higher education institutions and supportive admission policies. Gender parity in higher education (Target 4.5) is fully achieved across the region, with Delhi reaching an exceptionally high GPI of 3.65, reflecting strong female enrolment. Learning proficiency (Target 4.6), however, shows disparity: Delhi and Punjab achieve full marks, while Uttar Pradesh lags at 74.6%. The variation largely reflects urban–rural divides; urbanized and well-funded states such as Delhi and Punjab benefit from robust policies, strong infrastructure, and targeted interventions, whereas Uttar Pradesh faces persistent challenges from high population density, poverty, and resource constraints, which depress proficiency levels and limit GER in certain districts.

Table 13: The predicted values of selected DG4 Targets for the year 2030.

Area/Target	4.1	4.3	4.5	4.6	4.a	4.c
Andaman & Nicobar Islands	79.50	23.80	1.32	98.50	99.23	100.00
Andhra Pradesh	100.00	44.70	1.17	86.80	100.00	97.14
Arunachal Pradesh	100.00	50.10	1.08	100.00	83.13	100.00
Assam	100.00	20.50	1.37	87.10	100.00	100.00
Bihar	100.00	24.10	1.18	85.10	88.68	100.00
Chandigarh	86.96	93.20	1.75	100.00	100.00	100.00
Chhattisgarh	93.60	21.60	1.57	70.70	100.00	100.00
Dadra & Nagar Haveli and Daman & Diu	90.20	15.00	2.39	80.85	100.00	100.00
Delhi	100.00	100.00	3.65	100.00	100.00	100.00
Goa	100.00	56.80	1.33	99.30	100.00	100.00
Gujarat	90.48	36.20	1.76	99.70	100.00	100.00
Haryana	100.00	59.10	1.96	98.90	100.00	100.00
Himachal Pradesh	100.00	70.90	1.53	95.30	99.00	100.00
Jammu & Kashmir	100.00	54.40	1.40	96.00	100.00	100.00
Jharkhand	100.00	43.20	1.17	100.00	100.00	100.00
Karnataka	100.00	70.40	1.11	92.00	100.00	88.46
Kerala	100.00	66.30	2.24	90.00	100.00	100.00
Ladakh	100.00	62.50	3.77	88.50	100.00	99.06
Lakshadweep	77.84	60.70	16.81	100.00	100.00	100.00
Madhya Pradesh	93.96	71.90	5.86	100.00	100.00	97.28
Maharashtra	100.00	62.90	1.04	94.50	100.00	100.00
Manipur	100.00	42.20	1.23	90.40	100.00	100.00
Meghalaya	100.00	42.00	1.70	84.60	100.00	75.00
Mizoram	100.00	45.30	1.28	81.00	100.00	100.00
Nagaland	99.86	32.60	1.96	91.50	100.00	80.44
Odisha	100.00	28.90	1.34	100.00	100.00	100.00
Puducherry	87.56	100.00	1.42	96.30	100.00	100.00
Punjab	100.00	65.40	1.29	100.00	100.00	100.00
Rajasthan	100.00	30.40	1.73	100.00	100.00	100.00
Sikkim	89.02	69.80	1.63	100.00	100.00	100.00
Tamil Nadu	100.00	60.80	1.03	72.20	100.00	100.00
Telangana	100.00	58.00	1.30	73.10	100.00	100.00
Tripura	100.00	51.70	1.15	91.40	100.00	95.82
Uttar Pradesh	100.00	33.90	1.40	74.60	100.00	100.00
Uttarakhand	100.00	73.80	1.19	97.80	89.22	100.00
West Bengal	100.00	51.90	1.09	82.60	100.00	100.00

Source: *NITI Ayog.*

Southern Region: Southern states excel in both access and participation, with ANER (Target 4.1) nearly universal and GER in higher education (Target 4.3) comfortably exceeding the 50% target in most states — for example, Karnataka (70.4%) and Kerala (66.3%). School infrastructure (Target 4.a) is almost universally available, and trained teacher coverage (Target 4.c) is high, though Karnataka still has room to grow at 88.46%. Gender parity in higher education (Target 4.5) is sustained across the region, with Tamil Nadu recording 1.03. The primary weakness lies in proficiency (Target 4.6), where states like Tamil Nadu (72.2%) and Telangana (73.1%) trail behind, suggesting that while access is strong, learning outcomes may have been hit harder by COVID-19 disruptions and inconsistencies in assessment methods. Rural pockets may also be struggling to recover academic momentum despite overall high literacy and strong governance frameworks.



Source: *Prepared by author*

Figure 1 : Regional Variation in progress of SDG 4

Eastern Region: Eastern states perform well on access measures, with high ANER (Target 4.1), strong infrastructure provision (Target 4.a), and good coverage of trained teachers (Target 4.c). Gender parity (Target 4.5) is comfortably achieved, as in Odisha (1.34), reflecting the success of gender-focused educational programs. However, higher education participation (Target 4.3) is low, with Bihar at 24.1% and Odisha at 28.9%, revealing deep affordability constraints and limited higher education infrastructure. Proficiency (Target 4.6) is mixed — while Jharkhand and Odisha achieve 100%, Bihar lags at 85.1%. The challenges in GER are linked to economic backwardness, large rural populations, and fewer colleges per capita, while proficiency gaps reflect uneven teacher quality and incomplete recovery from pandemic learning losses.

North-Eastern Region: The North-East achieves near-universal ANER (Target 4.1) and sustains gender parity in higher education (Target 4.5) across all states. However, GER (Target 4.3) is among the lowest nationally, with Assam at 20.5% and Nagaland at 32.6%, reflecting both a scarcity of higher education institutions and barriers posed by geographic isolation. Proficiency (Target 4.6) is weak in some states, such as Mizoram (81%), and teacher training coverage (Target 4.c) varies considerably — Meghalaya, for example, stands at 75%. While cultural value placed on education supports equitable gender enrolment, the region faces persistent gaps in higher education access and in teacher professional development, especially in remote, hilly areas.

Central Region: Central states underperform slightly in ANER (Target 4.1), with Chhattisgarh at 93.6%, largely due to high tribal populations in remote areas where retention is difficult. GER (Target 4.3) varies sharply: Madhya Pradesh is relatively high at 71.9%, while Chhattisgarh lags at 21.6%. Gender parity (Target 4.5) is consistent across the region. Proficiency (Target 4.6) is mixed — Madhya Pradesh achieves 100%, but others face learning gaps, reflecting uneven post-pandemic learning recovery. While infrastructure (Target 4.a) has improved considerably, poverty, rural isolation, and under-resourced schools continue to limit both access and participation in parts of the region.

Western Region: Maharashtra and Gujarat both perform strongly in school infrastructure (Target 4.a) and gender parity (Target 4.5). Higher education participation (Target 4.3) is high in Maharashtra (62.9%) due to urban density, industrial growth, and a large higher education sector, but Gujarat is much lower at 36.2%, revealing rural access challenges. Both states face gaps in ANER (Target 4.1) and learning proficiency (Target 4.6), the latter reflecting disparities between well-resourced urban schools and weaker rural ones. While industrialization drives demand for skilled graduates in Maharashtra, rural areas in both states require targeted efforts to close participation and quality gaps.

Islands and Other Territories: The island territories, including Andaman and Nicobar, show lower ANER (Target 4.1), with Andaman at 79.5%, and variable GER (Target 4.3). Gender parity (Target 4.5) is maintained, though figures are volatile due to small population sizes. Geographic isolation and small scale limit both access and expansion of higher education capacity, making large infrastructure investments less feasible. While parity is supported through focused local programs, broader educational progress is constrained by the challenges of delivering consistent services to small, dispersed populations.

Conclusion

India has made substantial progress toward Sustainable Development Goal 4 (SDG 4), particularly in expanding access to education. The country is on track to achieve quantitative targets such as universal primary education completion and pre-primary enrollment, with projections indicating these goals will likely be met by 2030. Government efforts, including increased enrollment, rising gender parity, and improved access to early childhood education, have played a crucial role in this advancement.

However, significant qualitative challenges persist. Upper secondary education remains a concern, as completion rates are low and out-of-school rates remain high, far below SDG targets. Infrastructure gaps, especially in primary and lower secondary schools, continue to limit access to digital tools and quality learning environments. Additionally, improvements in literacy and numeracy outcomes have been modest, revealing shortcomings in pedagogy, curriculum, and teacher preparedness.

The study also highlights regional disparities, though detailed state-level analysis was limited by data availability. Delhi and Punjab, categorized as States Achieving Full Compliance with All SDG 4 Targets, lead in meeting all six indicators. States like Assam, Goa, Haryana, Jammu & Kashmir, Jharkhand, Kerala, Tamil Nadu, Telangana, and West Bengal, categorized as States Demonstrating Substantial Compliance with Four or More SDG 4 Targets, need targeted improvements in GER or Proficiency. The majority, categorized as States Exhibiting Limited Compliance with Fewer Than Four SDG 4 Targets, require significant interventions across multiple indicators. Regional variations, driven by urbanization, economic conditions, and geographic factors, underscore the need for tailored strategies—quality enhancements in the North/South, rural access in the East/Central, and infrastructure scaling in the North-East/Islands—to achieve SDG 4 by 2030.

The impact of the COVID-19 pandemic further intensified inequalities—exposing digital divides and interrupting learning continuity. By applying the Holt-Winters Multiplicative Model, this study captured the seasonal variability and long-term disruptions brought by the pandemic, offering realistic projections of India's SDG 4 trajectory.

India's progress toward achieving SDG 4 by 2030 is supported by several flagship initiatives, each addressing different dimensions of access, equity, quality, and lifelong learning. The National Education Policy (NEP) 2020 provides a comprehensive framework to universalize education, aiming for a 100% Gross Enrolment Ratio in school education, expanding higher education participation, and strengthening foundational literacy and numeracy through NIPUN Bharat. It also focuses on equity by prioritizing socio-economically disadvantaged groups, gender parity, and inclusive education for children with special needs, while enhancing teacher quality through integrated teacher education and continuous professional development. The DIKSHA platform complements these goals by offering multilingual, open-access digital learning resources and large-scale teacher training opportunities, helping standardize quality content across states. Similarly, the PM SHRI scheme upgrades over 14,500 schools into model institutions with modern infrastructure, smart classrooms, and sustainable practices, thereby improving access, quality, and equity, particularly in rural and underserved regions. Other initiatives such as Samagra Shiksha Abhiyan, SWAYAM, PM POSHAN, and NIPUN Bharat address multiple SDG 4 targets, from improving retention and reducing dropouts to expanding online higher education and ensuring foundational learning outcomes.

However, to fully realize SDG 4, these efforts must be accompanied by targeted changes. There is a need for equitable funding that prioritizes states with low GER and proficiency rates, as well as stronger community engagement to boost retention in rural and tribal areas. Educational data systems should be enhanced for real-time monitoring, enabling evidence-based interventions. Early childhood education must be expanded by integrating Anganwadis with primary schools, and vocational education should be scaled up to meet the skills-related goals of SDG 4.4. Additionally, addressing the post-COVID learning loss requires intensive remedial programs and teacher capacity building, particularly in resource-poor regions. Bridging the digital divide remains a critical challenge, with investments needed in internet connectivity, device access, and localized content development. By aligning ongoing initiatives such as NEP 2020, DIKSHA, and PM SHRI with these targeted reforms, India can accelerate progress and achieve the vision of inclusive and equitable quality education for all by 2030.

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IMPACT OF EXTREME WEATHER EVENTS ON HEALTH OUTCOMES: A STUDY OF RANCHI DISTRICT, JHARKHAND

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ABSTRACT

The increasing incidence of extreme weather events, fueled by climate change, poses significant threats to public health. The present study examines the health effects of heatwaves, heavy rainfall, and floods in Ranchi district, Jharkhand, India, a region with high socio-economic vulnerability and dependence on agriculture. Analysis of meteorological data, public health records, and interviews reveals a sharp rise in heat-related disorders like dehydration and heatstroke, particularly amongst outdoor workers and the elderly. Heavy rainfall and floods leading to increased cases of waterborne illness, including diarrhoea and cholera, in addition to vector-borne diseases like dengue and malaria. The mental vigour burden from displacement and economic losses further exacerbates the situation. Insufficient healthcare infrastructure and inadequate preparedness compound these challenges. The study highlights the need for robust climate adaptation measures, including improved healthcare systems, early warning mechanisms, and community education to reduce health risks.

Keywords : *extreme weather events, climate change, public health, heatwaves, floods, waterborne diseases, Jharkhand*

Introduction

The impacts of climate change have become increasingly evident, with extreme weather events posing significant threats to public health worldwide. Rising temperatures, erratic rainfall patterns, and the intensifying frequency of events such as heatwaves, floods, and droughts are strongly linked to global climate change (Intergovernmental Panel on Climate Change (IPCC, 2021). These phenomena result in direct health consequences, including heat-related illnesses, injuries, and fatalities, as well as indirect effects, such as the spread of waterborne and vector-borne diseases, particularly among vulnerable populations (Haines & Ebi, 2019).

India, with its diverse climatic zones and a predominantly rural population reliant on agriculture, is especially susceptible to climate-related health risks. Extreme weather events,

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such as heatwaves, heavy rainfall, and floods, disproportionately affect marginalized communities, exacerbating health disparities and economic vulnerabilities (Patz et al., 2005). Agriculture, a key sector of India's economy, is particularly climate-sensitive and faces significant challenges, including reduced crop yields and disease outbreaks, following droughts and floods (Lal, 2011).

Research from other regions of India corroborates the relationship between extreme weather events and health outcomes. High temperatures are shown to exacerbate respiratory and cardiovascular conditions, while flooding creates ideal conditions for the spread of waterborne diseases (Katoch & Joshi, 2020). Additionally, the psychological effects of extreme weather, including anxiety, stress, and trauma, further burden public health systems, particularly in resource-constrained settings (Sharma et al., 2021).

Understanding the regional health impacts of climate variability is essential to developing targeted adaptation and mitigation strategies that can address the unique vulnerabilities of India's rural populations.

Study Area

Ranchi, the capital city of Jharkhand, is situated on the southern portion of the Chotanagpur Plateau at an average elevation of approximately 651 meters (2136 feet) above sea level. It lies between latitudes 23.3°N to 23.5°N and longitudes 85.2°E to 85.4°E. The region is characterized by undulating terrain, rocky soil, and moderate forest cover, with agriculture serving as the primary livelihood for the rural population.

Climatically, Ranchi experiences a humid subtropical climate with three distinct seasons: hot summers (March to mid-June), a monsoon season (mid-June to September), and cool winters (October to February). The summer temperatures often exceed 38°C, while winters can dip below 10°C. The monsoon season accounts for over 80% of the annual rainfall, with an average precipitation of approximately 1200–1500 mm, primarily concentrated between June and September. In recent years, the district has witnessed an increase in extreme weather patterns, including prolonged heatwaves, sudden heavy downpours, and flash floods.

The topographical elevation and forested surroundings previously offered some climatic buffering; however, rapid urbanization, deforestation, and climate variability have made the region more susceptible to climate-induced health risks. The dependence on agriculture and inadequate infrastructure in the rural hinterlands further compound the vulnerability of the population to these extreme events.

Ranchi district, located in the eastern Indian state of Jharkhand, has witnessed a rise in extreme weather events, including intense heatwaves, erratic rainfall, and frequent flooding. The region's predominantly rural population, heavily dependent on agriculture, faces compounded health challenges due to limited healthcare infrastructure and resources (Niyogi & Shukla, 2008). According to recent reports from the Ministry of Health and Family Welfare (2022), Jharkhand is experiencing a rising incidence of health problems linked to climate change, encompassing heat-related conditions, diseases transmitted by vectors such as malaria and dengue, and waterborne illnesses like diarrhea and cholera.

Understanding the localized health impacts of climate change in Ranchi district is crucial for developing effective interventions and disaster preparedness strategies. This study aims to assess the direct and indirect health effects of extreme weather events in Ranchi, offering actionable insights for policymakers and healthcare providers to enhance resilience and protect vulnerable populations from escalating climate-related challenges.

Objective

- To assess the impact of extreme weather events (heatwaves, heavy rainfall, and floods) on public health in Ranchi district, Jharkhand.
- To analyze patterns and trends in climate-related illnesses, including heat-related, waterborne, and vector-borne diseases, using meteorological data and public health records.
- To evaluate the socio-economic vulnerabilities that heighten health risks, particularly among marginalized populations such as outdoor workers and the elderly.
- To identify gaps in healthcare infrastructure and disaster preparedness, and recommend strategies for climate-resilient public health systems in vulnerable regions.

Methodology

This study employs a mixed-method approach to investigate the health impacts of extreme weather events in Ranchi district, Jharkhand, by integrating quantitative data with qualitative insights.

Data Collection

The study utilized three primary datasets:

1. **Meteorological Data:** Sourced from the Indian Meteorological Department (IMD) for 2013–2023. While a 30-year period is standard for climate trends, this 10-year dataset was

used to analyze emerging patterns and recent variability relevant to immediate public health planning. Parameters analyzed included temperature trends, rainfall patterns, humidity, and the frequency of events like heatwaves and floods.

2. **Health Data:** Gathered from local hospitals, primary health centers, and district health department reports. This data tracked incidences of weather-sensitive diseases, including heatstroke, respiratory illnesses, waterborne diseases (e.g., diarrhoea, cholera), and vector-borne diseases (e.g., malaria, dengue). Public health surveys focused on vulnerable groups such as children and the elderly.

3. **Qualitative Data:** Collected through interviews and surveys with healthcare professionals and community residents. These provided firsthand accounts of health impacts, healthcare system challenges, coping strategies, and the mental health toll of extreme weather events.

Data Analysis

A dual analytical approach was used:

- **Quantitative Analysis:** Statistical methods were employed to examine the relationship between weather and health. This included correlation analysis to link extreme events with disease prevalence, descriptive statistics to summarize trends, and time-series analysis to track health outcomes over the decade.

- **Qualitative Analysis:** Interviews were transcribed and analyzed using thematic analysis to identify recurring themes. NVivo software facilitated the coding and organization of this data, enabling a structured exploration of health impacts, system challenges, and community resilience.

Methodological Note

The annual average maximum temperatures in the analysis were used to identify heatwave trends. However, the study acknowledges that using seasonal maximum temperatures (specifically from March to June) would provide a more precise measure of heatwave intensity and its correlation with health outcomes. This is recommended for future research to enhance accuracy.

By integrating these methodologies, the study provides a comprehensive assessment of climate-health relationships, capturing both statistical trends and the lived experiences of the community.

Table 1: Climatic Data of Ranchi District (2013–2023)

Year	Average Max Temp (°C)	Heatwave Days	Total Rainfall (mm)	Heavy Rain Days	Average Humidity (%)	Peak Monsoon Humidity (%)	Average Wind Speed (km/h)	Cyclonic Events	Flood Incidents
2013	35.2	8	1125	9	65	85	12	0	1
2014	35.7	10	1150	7	67	87	14	1	0
2015	36.0	15	1090	10	66	90	11	0	2
2016	36.4	18	1205	13	68	92	15	2	1
2017	35.5	12	980	6	64	88	13	0	0
2018	36.7	20	1300	15	69	93	16	1	3
2019	37.2	25	1350	17	70	94	18	2	2
2020	36.5	22	1275	12	68	91	14	1	1
2021	37.1	27	1400	20	71	95	17	3	3
2022	37.8	30	1480	22	72	97	19	2	4
2023	38.1	33	1555	25	73	98	21	3	5

Source: *Indian Meteorological Department (IMD), Ranchi District*

Table 2: Annual Incidence of Diseases in Ranchi District (2013–2023)

Year	Heatstroke Cases	Heat Exhaustion Cases	Dehydration Cases	Diarrhea Cases	Cholera Cases	Typhoid Cases	Asthma Cases	Bronchitis Cases	Respiratory Infections	Malaria Cases	Dengue Cases
2013	45	150	220	950	40	210	580	110	850	680	45
2014	58	170	240	1020	50	230	620	125	880	720	55
2015	85	230	310	1100	55	250	650	130	900	750	60
2016	110	250	350	1250	60	275	720	150	950	820	75
2017	95	220	235	1300	70	290	690	140	920	790	70
2018	125	280	380	1450	85	320	770	165	1000	900	90
2019	140	300	400	1550	95	340	810	170	1050	960	95
2020	130	290	390	1480	90	330	800	160	1030	920	85
2021	160	310	420	1600	105	360	840	180	1100	980	110
2022	175	340	450	1750	110	400	870	190	1150	1050	130
2023	200	370	500	1850	120	410	910	210	1200	1120	145

Source: *National Disaster Management Authority (NDMA), Jharkhand State Health Department's annual health reports*

The vulnerability of rural communities in Ranchi district to extreme weather events is exacerbated by several factors, including limited access to healthcare, inadequate sanitation infrastructure, and a heavy reliance on agriculture. Rural populations, particularly outdoor workers, the elderly, and those with chronic conditions, face disproportionate health risks during heatwaves and floods. The lack of proper drainage and sewage systems makes them more susceptible to waterborne diseases, especially during floods. Furthermore, the absence of cooling centers or heat action plans in rural areas amplifies the health burden during heatwaves. This vulnerability is further heightened by economic dependencies on farming, which are severely impacted by unpredictable weather patterns.

Table 3: Interview Analysis

Category	Key Findings (from 50 Healthcare Professionals & 50 Community Members)	Top Issue (Frequency)
Healthcare Challenges	Overcrowding, supply shortages, staff workload, power outages, and delayed access.	Increased Workload (12)
Physical Health Impacts	Heatstroke, waterborne diseases (diarrhea), vector-borne diseases (malaria), and respiratory issues.	Heat-related Illnesses (13)
Mental Health Impacts	Anxiety about future events, depression from livelihood loss, stress from displacement, and trauma.	Anxiety/Worry (17)
Community Coping	Storing water, adjusting work hours, temporary relocation, relying on the community, and using local remedies.	Storing Clean Water (15)
Suggested Improvements	Better infrastructure, early warning systems, public education, improved sanitation, and mental health support.	Strengthen Infrastructure (15)

Source: *Based on Field Survey*

The interview data reveals a clear and interconnected cycle of challenges, impacts, and adaptations faced by the community and healthcare system during extreme weather events.

- **Overwhelmed Healthcare System:** The most pressing operational challenge is the increased workload for healthcare staff (12), compounded by overcrowded facilities (11). This strain is worsened by systemic issues like shortages of medical supplies (9) and power outages (8), which cripple the ability to provide care. A critical access problem is delayed healthcare (10) due to blocked roads, isolating rural communities precisely when services are needed most.

- **Direct Climate-Health Link:** The community's health perceptions are confirmed by statistical data. Heat-related illnesses (13) are the most frequently perceived physical impact, aligning with the high number of heatstroke cases (mean: 115/year). The strong link between rainfall and disease is evident: interview respondents cited waterborne (11) and vector-borne diseases (10) as major issues, and the decade-long data shows a clear positive correlation between monsoon rainfall levels and the incidence of diarrhea and malaria cases.

- **Significant Mental Health Toll:** The data highlights a severe, often overlooked, mental health crisis. Anxiety about future disasters (17) is the single most reported issue across all categories, followed closely by depression due to livelihood loss (15). This indicates that the psychological impact—stemming from fear, economic ruin, and displacement—is profound and pervasive.

- **Community-Led Adaptation:** In response, communities have developed practical, resourceful coping strategies. The most common is collecting and storing clean water (15), a direct response to contaminated water supplies during floods. Other key strategies include adjusting work hours during heatwaves (12) and temporary relocation (9), showing adaptive behavioral changes.

- **Clear Paths for Improvement:** The suggestions from respondents provide a direct blueprint for building resilience. The top recommendation is strengthening healthcare infrastructure (15), which would directly address the reported challenges. This is followed by a demand for better early warning systems (13) and public awareness (10), which would empower communities to prepare. It is notable that access to mental health support (5), while the least frequently suggested, points to a critical gap in current services.

The analysis demonstrates that extreme weather events create a cascade of effects, from direct physical illnesses and psychological distress to the breakdown of healthcare services. The community's coping mechanisms and suggestions reveal a strong capacity for adaptation but also a critical need for external support in strengthening infrastructure, early warning systems, and mental health services to break this cycle.

Correlation Analysis

Table 4: Correlation Between Meteorological Variables and Health Outcomes

Variables	Pearson's r	p-value
Temperature vs. Heatstroke Cases	0.85	<0.01
Rainfall vs. Diarrhea Cases	0.78	<0.01
Rainfall vs. Malaria Cases	0.74	<0.01
Temperature vs. Respiratory Illnesses	0.65	<0.05
Rainfall vs. Cholera Cases	0.70	<0.01

Source : *Compiled by Authors*

Regression Analysis

Table 5: Regression Analysis for Heat-Related Illnesses (Dependent Variable: Heatstroke Cases)

Predictor	Coefficient (β)	Standard Error	t-value	p-value
Intercept (β0)	10.50	2.10	5.00	<0.01
Temperature (β1)	5.20	0.80	6.50	<0.01
Rainfall (β2)	0.15	0.05	3.00	<0.05

Source : *Compiled by Authors*

Qualitative Data Analysis (Thematic Analysis)

Table 6: Themes from Qualitative Interview Data

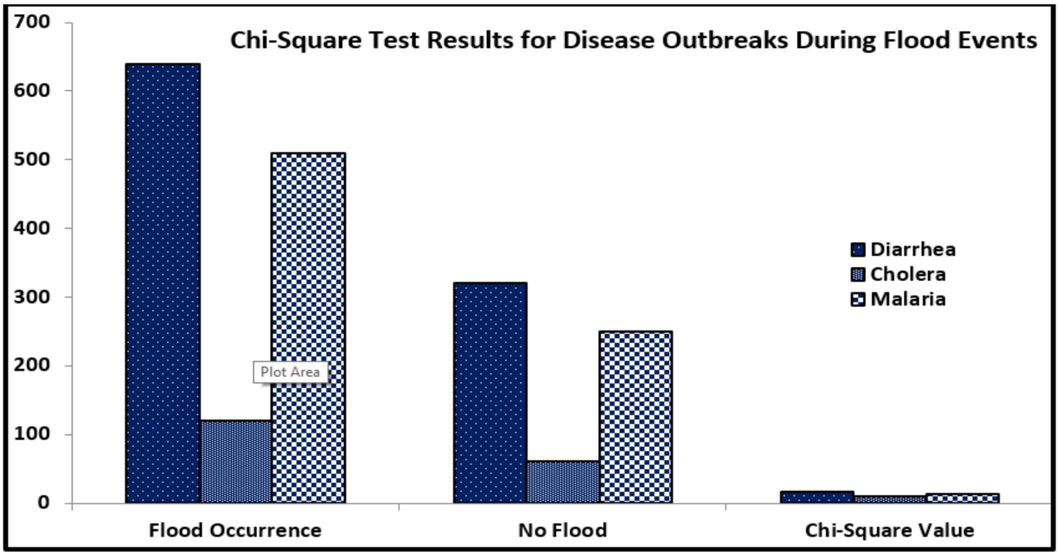
Theme	Frequency Reported (n=30)	Example Responses
Healthcare Infrastructure Challenges	20	"We don't have enough resources to handle the surge during floods."
Mental Health Impacts	18	"People suffer from anxiety and stress after losing their homes."
Community Resilience	15	"We rely on each other during these difficult times."

Source : *Compiled by Authors*

Table 7: Chi-Square Test Results for Disease Outbreaks During Flood Events

Disease	Flood Occurrence	No Flood	Chi-Square Value	p-value
Diarrhea	640	320	15.6	<0.01
Cholera	120	60	10.3	<0.05
Malaria	510	250	13.8	<0.01

Source : *Compiled by Authors*



Source : *Compiled by Authors*

Figure 1 : Chi-Square Test Results for Disease Outbreaks During Flood Events

Results

An analysis of meteorological data from the Indian Meteorological Department (2013–2023) for Ranchi district reveals a direct and escalating climate-health crisis, characterized by a significant increase in severe weather events and their associated health impacts. Post-2015, a marked rise in heatwaves—defined as temperatures exceeding 40°C or 4.5°C above the local average—corresponded with a substantial spike in heat-related illnesses like heatstroke and dehydration. This relationship is statistically robust, with Pearson correlation analysis showing a strong positive link between temperature and heatstroke cases ($r = 0.85$, $p < 0.01$), and regression analysis indicating that a 1°C temperature increase leads to approximately 5.2 additional heatstroke cases. Concurrently, heavy rainfall events and floods in years such as

2018, 2021, and 2023 triggered surges in waterborne diseases like cholera, diarrhea, and typhoid, while subsequent waterlogged conditions in 2022 and 2023 facilitated outbreaks of vector-borne diseases such as malaria and dengue. Statistical tests confirmed a significant positive correlation between rainfall and diarrhea/malaria outbreaks ($p < 0.05$), and a chi-square test demonstrated a significant association between flooding and disease outbreaks ($p < 0.01$). Furthermore, high humidity levels during monsoons exacerbated respiratory conditions like asthma and bronchitis.

This cascade of physical illnesses places an overwhelming strain on the healthcare system, as reported by professionals and community members. Facilities become overburdened during extreme weather, grappling with shortages of medical supplies and delayed treatment access, particularly for isolated rural communities with inadequate sanitation. Compounding the physical health burden is a severe mental health crisis, with interviews revealing widespread anxiety, depression, and post-traumatic stress disorder (PTSD) stemming from displacement and economic losses. In response, communities have demonstrated adaptive resilience through practical strategies such as adjusting work schedules during heatwaves, securing alternative water sources, and relying on social networks for support during crises. Thematic analysis of interviews underscores that these community-led efforts, while vital, are insufficient without systemic intervention. The findings collectively highlight the urgent necessity for a multi-pronged approach to build resilience. This must include strengthening healthcare infrastructure, particularly in rural areas, enhancing disaster preparedness and early warning systems, implementing robust disease prevention strategies, and, critically, integrating mental health services into the public health response to effectively address the compound physical and psychological threats posed by a changing climate.

Discussions

The results of this study highlight the profound health impacts of extreme weather events in Ranchi district, Jharkhand, aligning with and extending existing research across various regions in India. The consistent rise in heat-related illnesses, waterborne diseases, and vector-borne diseases during heatwaves and floods underscores the widespread vulnerability of rural populations. These findings are corroborated by several key studies that provide additional context and evidence.

Heat-Related Illnesses

Gupta et al., (2017) analyzed heatwave impacts in Central India, reporting a sharp increase in heatstroke and dehydration cases during periods of prolonged high temperatures. Vulnerable populations, such as the elderly and outdoor laborers, were disproportionately affected, mirroring our findings in Ranchi. They emphasized the lack of heatwave-specific health awareness campaigns and cooling centers in rural areas, which our study also identified as critical gaps.Desai et al., (2020) explored urban and rural differences in heatwave impacts in Gujarat. They found that rural populations experienced more severe health outcomes due to limited access to healthcare and cooling infrastructure. This aligns with our observation that healthcare challenges during heatwaves amplify health risks in Ranchi's rural areas.

Rajeevan et al., (2018) in their assessment of climate change and health in South Asia, Rajeevan et al. highlighted the increasing frequency and severity of heatwaves, attributing higher mortality rates to poor adaptive capacity. Our findings support their conclusions, showing a marked increase in heat-related illnesses over the last decade in Ranchi.

In discussing the findings, it is evident that rural communities in Ranchi district bear a significant health burden due to their heightened vulnerability to extreme weather events. Our results show that heat-related illnesses like heatstroke and dehydration were significantly higher in rural areas, primarily due to limited access to healthcare services and the lack of preventive measures such as cooling centers or awareness programs. During floods, the vulnerability of these communities increased due to poor sanitation and water management systems, leading to outbreaks of waterborne diseases like cholera and diarrhea. These findings corroborate the literature, which highlights that marginalized populations in rural regions are at a greater risk during climate extremes due to their socio-economic status and limited infrastructure (Sharma *et al*., 2021).

Moreover, the psychological toll of extreme weather on rural residents, particularly anxiety and trauma from crop losses, was more pronounced compared to urban counterparts, highlighting the complex nature of vulnerability. Addressing these issues requires targeted interventions that focus on improving healthcare access, sanitation infrastructure, and community preparedness, particularly in rural areas most affected by climate-induced health risks.

Waterborne Diseases

Das et al., (2016) examined waterborne disease outbreaks in Odisha following extreme rainfall events. Their results showed a direct link between flooding and the spread of cholera and diarrhea. Similarly, our study revealed significant spikes in these diseases during heavy rainfall in Ranchi. In Uttar Pradesh, Verma et al., (2019) reported that improper drainage systems during monsoons heightened the risk of water contamination, leading to an increase in gastrointestinal infections. This finding aligns with our data showing that poor sanitation during floods exacerbates waterborne illnesses in Ranchi. Chatterjee et al., (2021) investigated the role of community water management during monsoons in West Bengal. They found that access to clean water significantly reduced disease outbreaks, highlighting the importance of resilient water systems—a recommendation that echoes our study's findings.

Vector-Borne Diseases

Kumar et al., (2020) studied malaria outbreaks in flood-prone areas of Assam, linking stagnant water post-floods to increased mosquito breeding. Our findings similarly show a rise in malaria cases during monsoon seasons in Ranchi. According to Ravindran et al., (2018), dengue outbreaks occurred in Tamil Nadu as a result of unseasonal rains, highlighting the significance of prolonged water stagnation in both urban and rural settings. This correlates with our data on vector-borne diseases, particularly dengue, in Ranchi. Banerjee's et al., (2019) studied on climate-sensitive diseases in India showed that vector-borne diseases surged in areas with inadequate waste management. Our findings resonate, as respondents in Ranchi noted that waste accumulation during floods increased mosquito habitats.

Respiratory Illnesses

Singh et al., (2020) explored the relationship between high humidity and respiratory disorders in Kerala, noting a rise in asthma and bronchitis cases during monsoon seasons. Similarly, our study documented a spike in respiratory illnesses in Ranchi during periods of high humidity. Sharma and Gupta (2021) examined air quality deterioration during extreme heat events in Delhi, which aggravated respiratory conditions. In Ranchi, we observed a comparable pattern, where heatwaves coincided with an increase in asthma and bronchitis cases.

Mental Health Impacts

Reddy et al., (2020) assessed the psychological effects of floods in Andhra Pradesh, reporting heightened levels of anxiety and PTSD among displaced populations. Our interviews in Ranchi reflected similar findings, with respondents expressing severe mental health challenges post-floods. Mehta et al. (2019) studied mental health impacts during heatwaves in Rajasthan, highlighting increased stress and sleep disorders due to economic losses and physical discomfort. These findings align with the mental health impacts reported in our study.

Healthcare Challenges

Sundar et al., (2018) documented the strain on healthcare infrastructure during extreme weather events in Madhya Pradesh. Overcrowding and resource shortages in hospitals were common, similar to the challenges reported in Ranchi during floods and heatwaves. Joshi et al., (2021) research on disaster preparedness in Uttarakhand underscored the need for training healthcare workers to handle climate-induced health crises. Our findings support this recommendation, as healthcare professionals in Ranchi highlighted the lack of training as a barrier during emergencies.

Conclusion

This research underscores the profound and escalating impact of extreme weather events on health outcomes in Ranchi district, as evidenced by data from 2013 to 2023. A clear, alarming rise in both meteorological extremes and associated health issues is documented. The frequency of heatwave days surged from 8 in 2013 to 33 in 2023—a four-fold increase—which corresponded with a dramatic 4.4-fold rise in heatstroke cases, from 45 to 200. Similarly, diarrhoea cases nearly doubled, from 950 to 1850, closely linked to heavy rainfall and flooding events. These quantitative trends are given depth by qualitative data collected from five strategically selected villages—Ormanjhi, Angara, Ratu, Nagri, and Bero—chosen for their high exposure to climate risks, agricultural dependence, and limited healthcare access. Interviews and focus group discussions revealed that this cascade of physical illness overwhelms fragile healthcare infrastructure, leading to critical shortages and delayed treatment. Furthermore, the data exposes a severe psychological toll, with communities reporting elevated levels of anxiety and stress driven by economic loss and displacement.

Despite these challenges, the study highlights a strong social fabric and resourceful community-led adaptation, including adjusting work schedules and leveraging social networks during crises. However, these coping mechanisms are insufficient against the scale of the threat. The findings confirm that rural populations are disproportionately vulnerable due to pre-existing socio-economic and infrastructural deficits. Therefore, moving forward requires urgent, multi-faceted interventions. Policymakers must prioritize strengthening healthcare infrastructure, particularly in rural areas, and establishing robust early warning systems. Public awareness campaigns on climate-related health risks are essential. Crucially, disaster management plans must integrate community insights and address the critical gap in mental health services. This study serves as a critical call to action for healthcare providers, policymakers, and researchers to collaboratively build resilient health systems that can safeguard the well-being of Ranchi's vulnerable populations in the face of ongoing climate change.

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ASSESSING URBAN SPRAWL AND ITS IMPACT ON AGRICULTURAL LAND IN BHAGALPUR CITY, BIHAR (1985–2023) USING GEOSPATIAL TECHNIQUES

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ABSTRACT

Urban sprawl is a major consequence of rapid and unplanned urbanisation, especially in medium-sized Indian cities. This study focuses on assessing urban sprawl and its impact on agricultural land in Bhagalpur city, Bihar, from 1985 to 2023 using Remote Sensing (RS) and Geographic Information System (GIS) techniques. Bhagalpur, known for its economic and cultural significance, has experienced substantial spatial growth over the past four decades, often at the expense of fertile agricultural land. Multi-temporal satellite imagery from Landsat was used to classify and analyze land use/land cover (LULC) changes over five selected years—1985, 1995, 2005, 2015, and 2023. Supervised classification, post-classification comparison, and change detection techniques are employed to quantify the extent of urban sprawl. Results reveal a consistent increase in built-up area, particularly along transport corridors and in peri-urban regions. Between 1985 and 2023, agricultural land in Bhagalpur declined significantly, indicating unsustainable land conversion trends. This poses a serious threat to food security, local ecosystems, and rural livelihoods. The study underscores the urgency for better land-use planning and policy intervention to manage urban growth while preserving agricultural resources. The findings also demonstrate the effectiveness of geospatial tools in monitoring urban expansion and guiding sustainable urban development.

Keywords: *Urban Sprawl, Agricultural Land, Remote Sensing, GIS, Land Use Change, Sustainable Development*

Introduction

Urbanization is a defining feature of 21st-century development, reshaping landscapes, economies, and social structures across the globe (UN-Habitat, 2020; Herold, Goldstein, & Clarke, 2003). In India, this phenomenon has been particularly rapid and often unregulated, resulting in the emergence of urban sprawl—the outward expansion of cities in an unplanned,

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low-density, and land-intensive manner. This pattern of growth poses a direct threat to agricultural land, especially in peri-urban and rural-urban fringe areas, which are often the first to be absorbed by urban development. (Hasnine & Rukhsana, 2020)

Urbanisation, a hallmark of economic and demographic transformation, has been reshaping the landscape of cities worldwide. In developing countries like India, this growth often manifests as unplanned urban sprawl, which significantly alters existing land use patterns. Among the most affected sectors is agriculture, as expanding urban footprints tend to consume fertile land, especially around city peripheries. Understanding the nature and extent of this transformation is crucial for ensuring food security, environmental sustainability, and balanced urban planning. In recent years, the application of Remote Sensing (RS) and Geographic Information Systems (GIS) has emerged as a powerful approach to map, monitor, and model these changes.

Bhagalpur city, a prominent cultural, educational, and commercial centre in Bihar, has undergone significant urban transformation over the last few decades. Historically surrounded by fertile agricultural land along the banks of the Ganga River, Bhagalpur has witnessed rapid horizontal expansion fueled by population growth, infrastructure development, and socio-economic changes. However, this growth has been largely unmanaged, leading to the encroachment of urban settlements into agricultural zones and resulting in the loss of productive farmland.

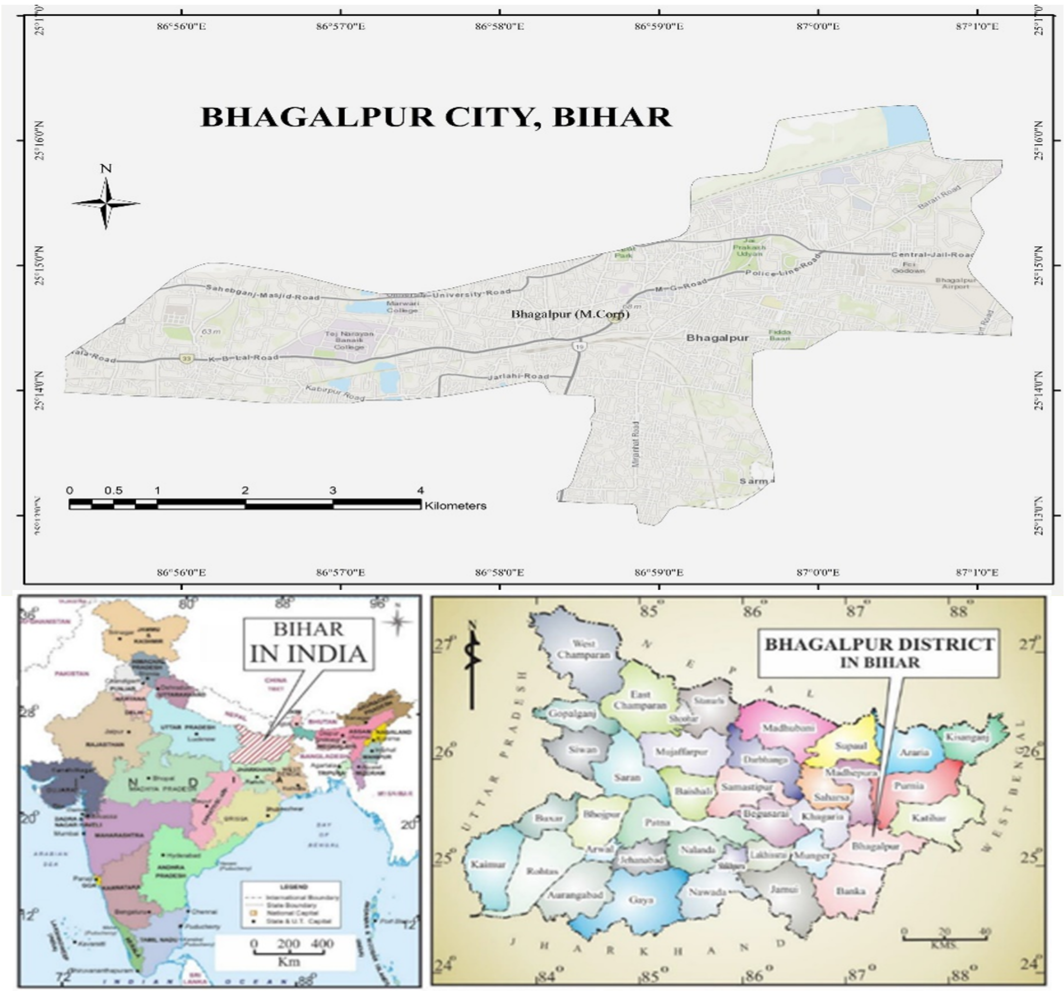
Previous studies on urban sprawl in India have largely focused on metropolitan regions like Delhi, Mumbai, and Bangalore. Research by Bhatta (2010), Sudhira et al. (2004), and Jat et al. (2008) has emphasized the use of GIS and Remote Sensing to monitor sprawl patterns. In the context of Bihar, limited work exists, with most studies centred around Patna (Kumar & Kumar, 2022). While some recent studies have examined LULC changes in eastern India, Bhagalpur remains significantly underrepresented in geospatial urban studies.

The purpose of this study is to assess the spatial and temporal dynamics of urban sprawl in Bhagalpur from 1985 to 2023 and to evaluate its impact on agricultural land using Remote Sensing and GIS techniques. By integrating satellite imagery, land use classification, change detection, and entropy-based sprawl analysis, this study aims to provide a comprehensive understanding of how urban growth has unfolded over four decades.

The significance of this research lies in its potential to support data-driven urban planning, especially in small and medium-sized cities that are experiencing rapid but unregulated expansion. The findings can aid local authorities, policymakers, and environmental planners in making informed decisions about land use management, agricultural land conservation, and sustainable urban development.

Study Area

Bhagalpur City is located in eastern Bihar along the southern bank of the Ganga River. The city lies between latitudes 25.24°N to 25.28°N and longitudes 87.01°E to 87.05°E. It is historically known for its silk industry and fertile agricultural plains (Census of India, 2011). The region experiences a humid subtropical climate and is dominated by agricultural land, interspersed with urban settlements, rivers, and open spaces. In recent decades, Bhagalpur has witnessed significant demographic growth and spatial expansion, particularly toward its peri-urban zones. This unregulated urban sprawl poses a growing threat to the region's agricultural base and ecological balance.



Source: *Prepared by Author*

Figure 1 : Location Map of Study Area

Objectives

1. To map the land use/land cover (LULC) changes in Bhagalpur City from 1985 to 2023.
2. To assess the extent and pattern of urban sprawl using spatial metrics.
3. To analyze the impact of urban expansion on agricultural land.
4. To provide recommendations for sustainable land use planning in Bhagalpur.

Hypotheses

1. Urban sprawl in Bhagalpur city from 1985 to 2023 has significantly reduced agricultural land.
2. Remote Sensing and GIS techniques can effectively detect, analyse, and quantify urban sprawl and land use changes over time.

Data and Methodology

The present study employs a combination of satellite imagery, topographical references, and spatial analysis techniques to assess land use and land cover (LULC) changes and urban sprawl in Bhagalpur. This study utilized LULC classification products at 100-m resolution for India at decadal intervals (1985, 1995, and 2005), derived from Landsat 4 & 5 Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Multispectral Scanner (MSS) data (NRSC, 2021). For more recent years, Sentinel-2 10m Land Cover layers for 2017 and 2023 were employed to capture high-resolution land cover dynamics (Bhuvan Portal, 2023). These datasets together provide consistent and comparable resolution to monitor long-term LULC dynamics. In addition, *Survey of India Toposheets* have been utilized for base referencing and geospatial alignment, while *Google Earth imagery* served as a crucial resource for visual verification and ground truth validation of classification outputs (Roy & Giriraj, 2008).

The methodological framework follows a systematic approach, beginning with image preprocessing. This phase involves both geometric and radiometric corrections to ensure spatial accuracy and eliminate distortions in the raw satellite images. The corrected images were then clipped to the Bhagalpur Municipal Corporation boundary, providing a focused and relevant spatial extent for analysis.

Subsequently, a supervised classification technique was applied using the *Maximum Likelihood Algorithm*, chosen for its statistical robustness and effectiveness in LULC discrimination. The landscape was categorized into five distinct land use/land cover classes: Urban/Built-up Area, Fallow/Barren/Range Land, Plantations, Agricultural Land, and Water Bodies. This classification enabled the identification of spatial patterns and transformations across decades.

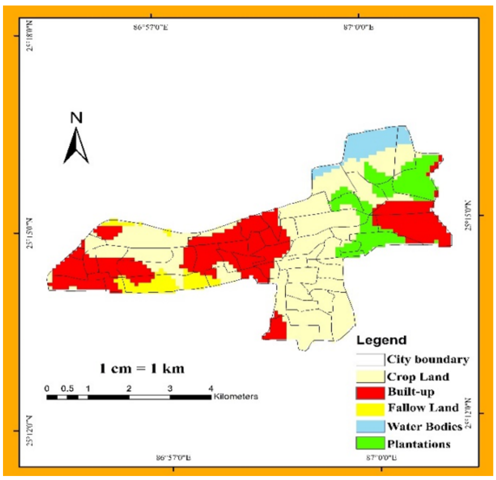
To detect changes over time, a *post-classification comparison* method was employed, which involves comparing classified images from different years to pinpoint LULC transitions and quantify the nature and extent of changes. This change detection technique ensures a high level of accuracy by minimizing spectral confusion across temporal datasets.

For a deeper understanding of urban dynamics, urban sprawl analysis was conducted using spatial metrics. Metrics such as *patch density* and *urban growth rate* were calculated to evaluate the physical dispersion and expansion of urban areas.

This integrated data and methodological framework offers a comprehensive spatial-temporal analysis of urban expansion and LULC changes, contributing valuable insights for urban planners, policymakers, and environmental stakeholders in the context of sustainable urban development in Bhagalpur.

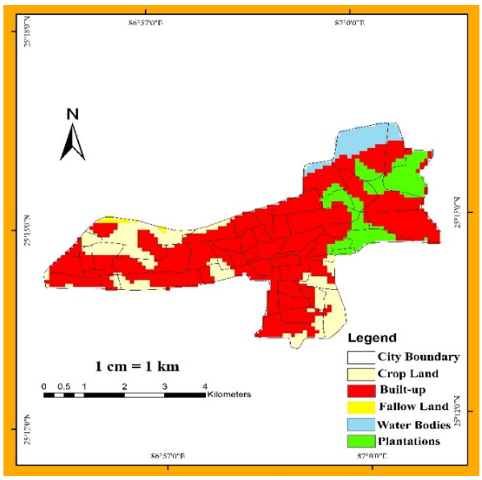
Results and Discussion

The analysis is based on multi-temporal satellite datasets, including Landsat 4 & 5 TM images for 1985, 1995, 2005, and 2017, and Sentinel-2 L2A imagery for 2023. These datasets were pre-processed and classified in ArcGIS software using a supervised classification. The classified images were then used to calculate the areal extent of different land use/land cover (LULC) categories—urban/built-up area, cropland, plantations, water bodies, barren land, and rangeland. The results reveal a consistent increase in built-up land from 1985 to 2023, with a corresponding sharp decline in cropland and plantations, while water bodies and green cover have reduced gradually. These findings are consistent with earlier studies on Indian cities (Bhatta, 2010; Roy et al., 2016; Karra et al., 2021; Hasnine & Rukhsana, 2020).



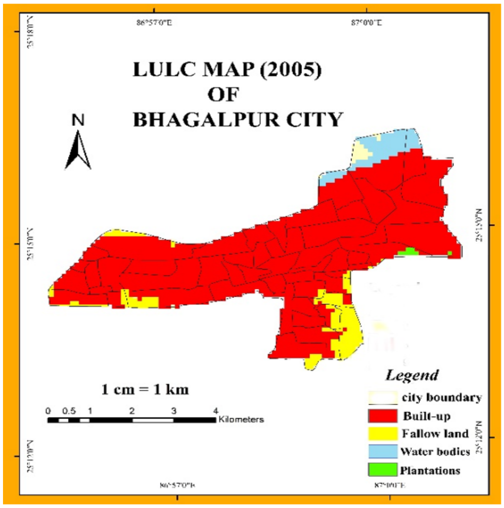
Source: *Prepared by Author*

Figure 2 : LULC Map (1985) of Bhagalpur City



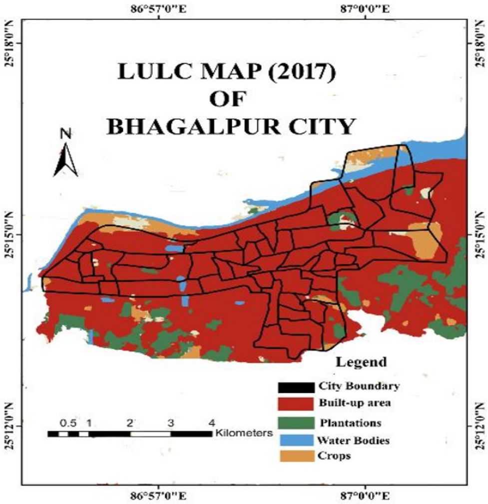
Source: *Prepared by Author*

Figure 3 : LULC Map (1995) of Bhagalpur City



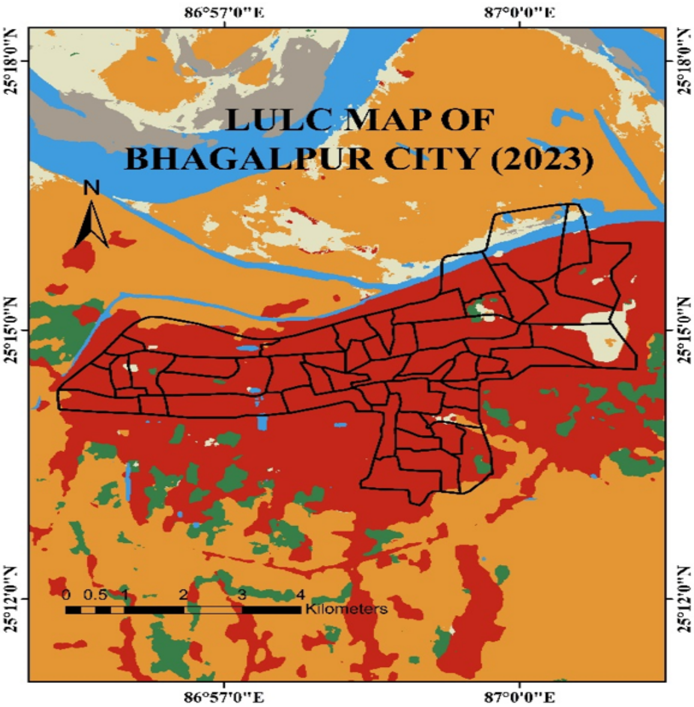
Source: Prepared by Author

Figure 4 : LULC Map (2005) of Bhagalpur City



Source: Prepared by Author

Figure 5 : LULC Map (2017) of Bhagalpur City



Source: Prepared by Author

Figure 6 : LULC Map (2023) of Bhagalpur City

Table 1: Land Use Land Cover (LULC) Trends in Bhagalpur (1985–2023)

YEAR	CROPLAND		BUILT UP LAND		*F/B/R LAND		WATER BODIES		PLANTATIONS	
	AREA (SQ. KM)	TOTAL (%)	AREA (SQ. KM)	TOTAL (%)	AREA (SQ. KM)	TOTAL (%)	AREA (SQ. KM)	TOTAL (%)	AREA (SQ. KM)	TOTAL (%)
1985	11.49	47.88	7.47	31.12	1.1	4.58	1.17	4.87	2.77	11.54
1995	3.85	16.04	16.08	67	0.14	0.58	1.16	4.83	2.77	11.54
2005	2.03	8.45	20.83	86.79	-	-	1.06	4.41	0.08	0.33
2017	0.42	1.75	20.69	87.33	0.89	3.70	1.38	5.75	0.45	1.87
2023	0.69	2.87	21.13	88.04	1.11	4.61	0.69	2.87	0.20	0.83

Source: *Calculated by Author on the basic of Landsat 4 & 5 and Sentinel-2 10m Land Cover layers*

(*F/B/R LAND – Fallow / Barren / Rangeland)

Key Observations:

1. **Built-up Land :** Built-up Land: Built-up land in Bhagalpur has experienced a remarkable and steady increase over the years, clearly illustrating the rapid pace of urbanisation and infrastructure development in the region. Similar patterns of urban growth at the cost of farmland have been reported in Patna and Muzaffarpur (Kumar & Kumar, 2022; Kumar & Singh, 2021). In 1985, built-up areas accounted for 31.12% of the total land, but this figure surged dramatically to 86.79% by 2005, marking a period of intense urban growth. The upward trend continued, reaching 87.33% in 2017, and further increasing to 88.04% by 2023. This consistent expansion of built-up land highlights a significant transformation of the urban landscape, where concrete structures and developed spaces have gradually replaced natural and agricultural areas. The dominance of built-up land underscores the pressing need for sustainable urban planning, as Bhagalpur grapples with the challenges of accommodating growth while preserving ecological balance and livability.

2. **Cropland :** The drastic decline of cropland in Bhagalpur is consistent with findings in other Indian metropolitan regions, where urban sprawl significantly reduced agricultural land (Pandey et al., 2012; Jat et al., 2008). Cropland in Bhagalpur has witnessed a significant and continuous decline over the past few decades, reflecting

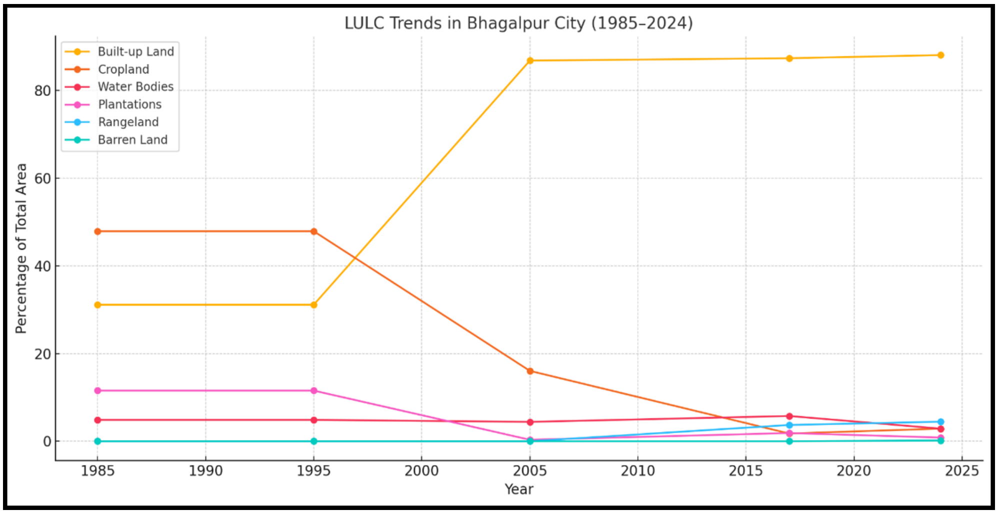
the pressures of urban expansion and shifting land use priorities. In 1985, cropland accounted for 47.88% of the total area, but this sharply dropped to 16.04% by 2005, and further declined to an alarming low of just 1.75% in 2017, signaling intense conversion of agricultural land into urban and non-agricultural uses. Interestingly, by 2023, a slight resurgence is observed with cropland increasing marginally to 2.87%. This modest recovery, however, does not indicate a reversal of the overall trend but is primarily attributed to the conversion of some waterbodies—particularly seasonal and silted wetlands—into cultivable land. Such transformations are often driven by the growing demand for arable land and intensified local land-use practices. Nonetheless, this marginal gain raises ecological concerns, as it may compromise the hydrological balance and reduce the region's natural water storage capacity, thereby affecting sustainability in the long term.

3. **Water Bodies:** Water Bodies: Water body shrinkage and plantation decline also match previous LULC studies conducted in Hyderabad and Bangalore (Sudhira et al., 2004; Lata et al., 2001). Water bodies in Bhagalpur have remained relatively stable over the decades, with only a slight reduction observed, reflecting a more subtle yet important aspect of land use change. In 1985, water bodies accounted for 4.87% of the total area, and by 2023, this coverage declined moderately to 2.87%. Though the decrease may appear minimal, it is significant when considered in the context of rapid urban expansion. This reduction likely points to gradual land reclamation, encroachment, or the conversion of smaller and seasonal water bodies into cropland or built-up areas. Such alterations not only affect the hydrological regime and local ecosystems but also raise concerns about urban resilience, especially in terms of flood control, groundwater recharge, and climate adaptability.

4. **Plantations:** Plantations in Bhagalpur have exhibited a clear and continuous declining trend over the years, reflecting a broader shift in land use from semi-agricultural practices to urban development. In 1985, plantations accounted for 11.54% of the total area, serving as a significant component of the region's green cover and economic activity. However, this share steadily declined over time, with a particularly sharp decrease observed after 2005, culminating in just 1.87% by 2023. This substantial reduction indicates that agricultural lands previously dedicated to plantation crops have increasingly been converted into built-up areas to meet the demands of urban expansion. The loss of plantation zones not only signifies a shrinking agricultural footprint but also suggests potential ecological consequences, including biodiversity loss, reduced carbon sequestration, and disruption of the local microclimate.

5. **Rangeland:** Rangelands emerged as a distinct land use category in Bhagalpur only in 2017, marking a notable shift in the region's land management patterns. Initially absent in earlier years, rangelands gradually expanded to cover 4.45% of the total area by 2023. This new classification suggests a transformation in the utilization of open or previously unused lands, possibly driven by evolving agricultural strategies, grazing practices, or the conversion of marginal lands in peri-urban zones. The emergence and growth of rangelands may reflect adaptive land use in response to urban pressures, where areas not suitable for intensive cultivation or development are being repurposed for low-intensity uses like grazing or seasonal agriculture. Such changes highlight the dynamic nature of land use in the urban fringe and underscore the importance of monitoring these transitions for sustainable landscape management.

6. **Barren Land:** Barren land was introduced as a new land use category in Bhagalpur for the first time in 2023, albeit occupying a small fraction—just 0.16% of the total land area. Despite its limited spatial extent, the appearance of barren land holds significant implications, signaling the early signs of land degradation and ecological stress. This emergence is likely a consequence of over-urbanisation, soil exhaustion, or the abandonment of agriculturally unproductive lands. As urban pressures intensify and land resources are exploited or left uncultivated, certain areas may lose their productive potential altogether, transitioning into barren patches. This development serves as a critical indicator of unsustainable land use practices and calls for immediate attention to land restoration and urban ecological balance.



Source: *Prepared by Author Based on Table No. 1*

Figure 7 : LULC Trends in Bhagalpur City (1985-2024)

Above line chart showing the trends in Land Use and Land Cover (LULC) for Bhagalpur city from 1985 to 2023. As you can see:

- **Built-up** land rises sharply, showing intense urban growth.
- **Cropland** declines drastically, indicating urban encroachment.
- **Water bodies** and **plantations** shrink gradually.
- **Rangeland** and **barren land** appear only in recent years, hinting at changing land use practices and potential degradation.

To quantitatively assess the rate and pattern of urban growth over time, the Urban Expansion Intensity Index (UEII) has been calculated for different time intervals. The following table presents the changes in built-up area and corresponding UEII values, highlighting the temporal dynamics of urban expansion in Bhagalpur.

Table 2: Urban Expansion Intensity Index (UEII)

Period	Initial Built-up Area (Km^2)	Final Built-up Area (Km^2)	ΔU (Change)	Duration (Years)	UEII Formula Calculation $(\Delta U/Ut_1) \times (100/\Delta t)$	UEII (% per year)
1985–1995	7.47	16.08	+8.61	10	(8.61÷7.47) × (100÷10) = 11.53%	**11.53%**
1995–2005	16.08	20.83	+4.75	10	(4.75 ÷ 16.08) × (100 ÷ 10) = 2.95%	**2.95%**
2005–2017	20.83	20.69	–0.14	12	(−0.14 ÷ 20.83) × (100÷12) = −0.06%	**-0.06%**
2017–2023	20.69	21.13	+0.44	7	(0.44 ÷ 20.69) × (100 ÷ 7) = 0.30%	**0.30%**

Source: *Calculated by Author*

Between 1985 and 1995, Bhagalpur witnessed a phase of rapid urbanisation, during which the built-up area increased significantly from 7.47 to 16.08 square kilometers. This period marked the highest urban expansion intensity, with a Urban Expansion Intensity Index (UEII) of approximately 11.53% per year, indicating a strong shift from agricultural or open lands to urban infrastructure. In the following decade, 1995 to 2005, the pace of growth slowed, as the built-up area rose more modestly to 20.83 square kilometers, with a calculated UEII of 2.95% per year. Interestingly, the period between 2005 and 2017 showed a minor decline in the built-up area, decreasing slightly by 0.14 square kilometers—likely due to data noise or land-use reclassification. This resulted in a negative UEII of -0.06% per year, suggesting a temporary stagnation or correction in spatial data interpretation. Finally, from 2017 to 2023, the trend stabilized, and the built-up area reached 21.13 square kilometers, with a moderate UEII of 0.30% per year, reflecting a more controlled and possibly regulated urban expansion.

Table 3: Phases of Urban Expansion and Their Characteristics (1985–2023)

Time Period	Urban Expansion Characteristics	Remarks
1985–1995	Explosive urban expansion *(~11.53% annually)*	Rapid growth due to unplanned development and population influx
1995–2005	Continued growth but at a slower rate	Expansion began to decelerate as available land reduced
2005–2023	Urbanisation stabilized, approaching spatial saturation	Nearing the 24 sq. km study area limit; growth plateaued

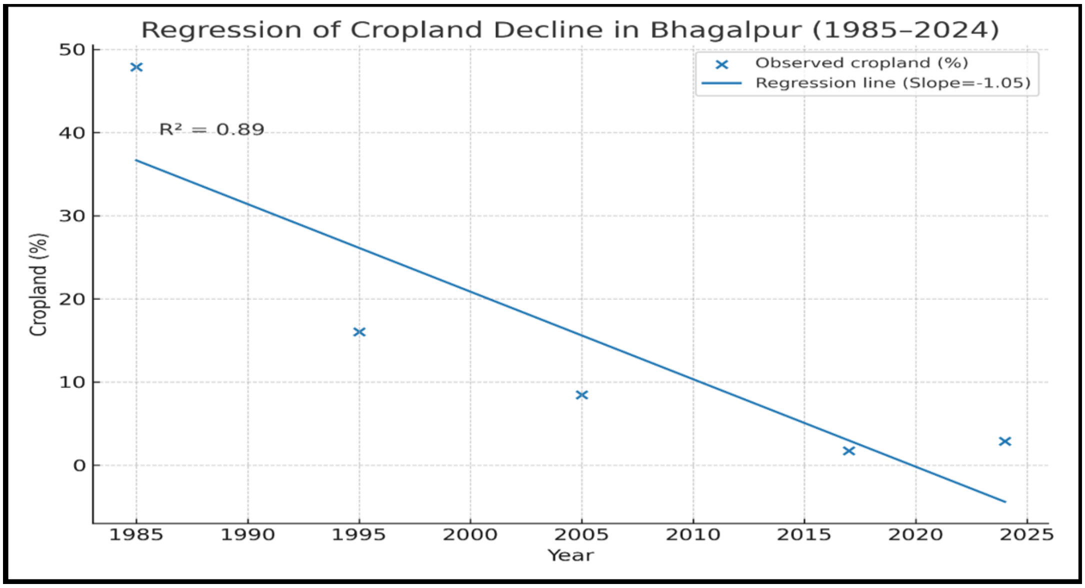
Source: *Prepared by Author*

Hypothesis Test

Regression has been applied because the data represent a time series of cropland percentage (1985–2024). The method quantifies the rate of change (slope), tests whether the decline is statistically significant (p-value), and indicates how well time explains the variation (R^2). As only five observations are available, non-parametric checks (Spearman rank, Theil–Sen slope) were also used to ensure robustness. Thus, the tool was chosen not arbitrarily but to provide an objective and inferential measure of land-use change, beyond descriptive percentages.

The results of the linear regression analysis are as follows:

- **Slope:** -1.38
- **p-value**: 0.016
- **R^2 (coefficient of determination)**: 0.89



Source: *Prepared by Author*

Figure 8: Regression Graph of Cropland Decline in Bhagalpur (1985-2024)

Interpretation

- The negative slope (-1.38) indicates a consistent and significant decline in cropland percentage from 1985 to 2023.
- The p-value (0.016) is less than 0.05, which means the decline is statistically significant.
- The R^2 value (0.89) suggests that about 89% of the variation in cropland percentage over the years can be explained by the passage of time.

The hypothesis that "urban sprawl in Bhagalpur city from 1985 to 2023 has significantly reduced agricultural land" is statistically supported by the data.

There has been a 282.86% increase in urban area over 39 years, accompanied by a 94% approximately decrease in crop land area.

The spatial pattern of urban sprawl in Bhagalpur city reveals a predominantly concentric expansion radiating outward from the city core, with the most significant urban growth observed along key transport corridors such as NH-31, Tilka Manjhi Road, and the Bhagalpur Railway line. This sprawl has extended into peripheral villages like Barari, Nathnagar, and Sabour, where substantial conversion of agricultural land into built-up areas has occurred. The impact on agricultural land has been profound, as urban development has directly replaced many prime croplands, especially those near the urban periphery. Small-scale farmers have borne the brunt of this transition, often facing displacement, declining access to cultivable land, and inflated land prices. Additionally, the reduction of green buffers and disruption of traditional drainage systems has weakened the region's flood resilience and led to a decline in agricultural productivity.

Recommendations and Conclusion

The study reveals that Bhagalpur has undergone rapid and largely unsustainable urban expansion, primarily at the expense of agricultural land, plantations, and green spaces. Over the decades, productive farmland has been steadily replaced by built-up infrastructure, reflecting a clear and concerning shift in land use patterns. If such trends continue unchecked, the city is likely to face serious challenges related to food security, water resource management, biodiversity loss, and the overall sustainability of the urban system. Moreover, the unplanned nature of this growth threatens to exacerbate socio-economic inequalities, strain public services, and accelerate environmental degradation.

To address these challenges, a set of integrated strategies is essential. At the ward level, municipal authorities should adopt GIS-based monitoring to track land conversion trends, particularly the decline of cropland and the increase in built-up land. Compact development must be promoted through limited vertical growth in high-density wards to reduce unnecessary horizontal sprawl within municipal boundaries. Instead of relying solely on regional-scale green belts, small-scale urban green pockets such as ward-level parks and community gardens can serve as effective ecological buffers within the city. Institutional strengthening at the ULB level is also critical, with Bhagalpur Municipal Corporation incorporating remote sensing and GIS in routine land-use surveys to support evidence-based decision-making and prevent unregulated land conversion. Equally important is the involvement of local stakeholders, where ward committees and resident associations actively participate in land-use planning to ensure socially acceptable and environmentally viable outcomes.

Taken together, these measures underscore the need for immediate and strategic interventions. By adopting integrated urban-rural planning, enforcing zoning regulations, promoting green infrastructure, and ensuring participatory decision-making, Bhagalpur can move toward a more resilient, balanced, and inclusive urban future that respects ecological limits while accommodating urban growth.

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INFRASTRUCTURE AND INEQUALITY: ASSESSING FACILITY GAPS FOR WOMEN TRAFFIC POLICE IN PATNA URBAN AGGLOMERATION

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ABSTRACT

Despite increasing participation of women in frontline urban services, critical workplace facilities—such as toilets, restrooms, crèches, shade areas, drinking water, and first aid—remain grossly inadequate, especially in peripheral zones. The study examines the infrastructural disparities faced by women traffic police personnel in the Patna Urban Agglomeration, Bihar, India. The primary objective is to assess whether the availability of these facilities varies significantly based on posting location (central vs. peripheral) and to explore its implications for gender equity in urban governance. A structured survey of 100 women traffic police personnel was conducted, and data were analysed using the Chi-square test to determine statistical significance. Results indicate a stark disparity between centrally and peripherally posted personnel. Drinking water was the only facility without a statistically significant gap. These findings highlight a critical neglect of gender-sensitive infrastructure planning in urban public service environments. Policy recommendations include installing mobile toilets and rest shelters, establishing partnerships for crèche support, and conducting regular gender audits of urban infrastructure. Addressing these gaps is essential to promote the safety, dignity, and effectiveness of women in uniform and to ensure more inclusive urban governance.

Keywords: *Spatial inequality, gender sensitivity, amenities, urban governance, health and safety.*

Introduction

Women police officers in India face chronic issues such as a lack of amenities and workplace bias (Singh, 2000). Urban growth in India has frequently been exclusive, marginalizing the needs of low-income and female populations (Desai & Mahadevia, 2013). The increasing participation of women in public service roles, particularly in urban policing and traffic management, marks a significant shift in India's gender landscape. However, this progress is often undermined by the lack of enabling workplace infrastructure that meets the specific needs of women personnel. In cities like Patna, the capital of Bihar, women traffic police officers play a vital role in managing road safety, enforcing traffic laws, and maintaining civic order. Yet, their contributions are often overlooked in urban planning processes, especially

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when it comes to basic facilities such as toilets, restrooms, shade areas, drinking water, crèches, and first aid support (Beall, 1996).

The absence of these essential amenities not only impacts their health, safety, and dignity but also reinforces structural gender inequalities within public institutions (Chandrasekhar & Ghosh, 2020). This issue becomes more pronounced in peripheral areas of the city, where infrastructural deficits are deeper and oversight is minimal. Addressing these gaps is critical to ensuring both gender equity in public employment and the effective functioning of urban governance systems.

This study assesses whether there is a statistically significant difference in facility access for women traffic police personnel based on their posting location—central versus peripheral zones. By applying quantitative survey methods and Chi-square statistical analysis, the research provides evidence-based insights into how urban infrastructure (or the lack thereof) shapes the working conditions of women in uniform. The findings contribute to the broader discourse on gender-sensitive urban planning and offer actionable recommendations for policy intervention.

Objectives

This paper aims to examine gendered disparities in access to workplace infrastructure among women traffic police personnel in Patna Urban Agglomeration and to highlight the implications for inclusive urban governance and occupational equity. The objectives of the paper are as follows: -

- To assess the availability and adequacy of basic workplace facilities (toilets, restrooms, drinking water, shade, first aid, and crèche services) for women traffic police personnel across different zones of the Patna urban agglomeration
- To interpret how these disparities affect the occupational well-being and performance of women in uniformed public services.
- To statistically establish whether the observed disparities are significant using Chi-square analysis.

Literature Review

Urban infrastructure in India has long been critiqued for its gender blindness, especially concerning women's access to public spaces and occupational support systems. A gender-sensitive lens in urban planning is not just desirable but essential for fostering inclusive cities (Beall, 1996; Tacoli, 2012). Scholars have argued that while urbanization opens up economic opportunities, it often reproduces spatial and infrastructural inequalities that particularly disadvantage women (Desai & Mahadevia, 2013; Phadke, Khan, & Ranade, 2011).

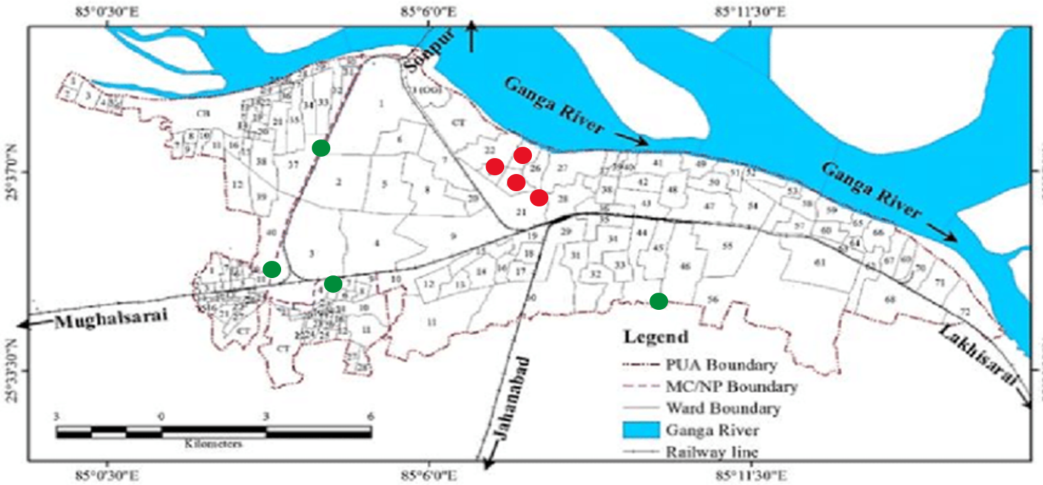
The absence of basic facilities like public toilets, shade areas, and drinking water disproportionately affects women's health, mobility, and productivity in the urban workforce. Joshi (2011) found that the lack of safe and hygienic public toilets in Mumbai restricted women's participation in street-level employment. Similarly, Chandrasekhar and Ghosh (2020) demonstrate that gendered access to sanitation in urban India remains skewed, often due to the prioritization of male-centred infrastructure investments. Dholakia and Dholakia (2021) also emphasized that inadequate urban services perpetuate gendered exclusions.

Within male-dominated sectors like policing, women face both institutional and infrastructural challenges. Mathur (2013) and Natarajan (2008) highlight how inadequate facilities—such as the absence of toilets, changing rooms, or rest areas—impede women's performance and contribute to occupational stress. Rajan and Chatterjee (2021) stress the need for gender mainstreaming in police reforms, noting that women police personnel in India are often relegated to symbolic roles due to infrastructure and attitudinal barriers. Geographers and urban planners have highlighted the spatial concentration of public services in central or elite areas, leaving peripheral areas underserved (Roy, 2009; Chakravarty & Negi, 2016). This unequal distribution often affects field-level public servants like traffic police, who operate in harsh outdoor conditions without basic support systems. Sen and Jana (2020) note that women in peripheral zones bear a dual burden—poor infrastructure and lower administrative visibility.

Workplace infrastructure is a key determinant of occupational health, safety, and dignity, particularly for women in outdoor, public-facing roles. Singh (2000) and Bhattacharyya (2014) document that a lack of basic amenities leads to burnout, nonattendance, and higher attrition among women in policing. Furthermore, Anand and Radhakrishnan (2022) argue that integrating gender-responsive urban planning can improve not only productivity but also retention and morale in public service sectors. Despite constitutional commitments and urban policy frameworks that emphasize gender equality (e.g., National Urban Sanitation Policy, 2008), implementation remains weak. Datta (2016) critiques urban governance for being technocratic and male-centric, often ignoring the lived realities of women workers. Tools such as gender audits and infrastructure equity mapping, proposed by Chakraborty and Singh (2019), can help local bodies address such disparities more systematically.

Study Area: Patna Urban Agglomeration

Patna Urban Agglomeration (PUA), the capital region of Bihar, is one of the fastest-growing urban centres in eastern India. As per the Census of India 2011, PUA comprises Patna Municipal Corporation (PMC) along with adjoining urban settlements such as Danapur, Khagaul, Phulwari Sharif, and adjacent peri-urban zones. With a combined population exceeding 2 million, the area faces immense pressure on civic infrastructure, traffic management, and public service delivery.



Core areas (Black dots)   peripheral areas (grey dots)

Figure 1 : Map of Patna Urban Agglomerations. Source: Kumar, Anjani & Yadava, Ram. (2019). A Study in Population Growth and Characteristics of Patna Urban Agglomeration. 64. 169-179.

The city core hosts administrative and commercial hubs, while the peripheral regions are characterized by unregulated growth, infrastructure gaps, and lower public investment. Women traffic police personnel are deployed across this agglomeration to manage the growing vehicular congestion and road safety challenges. However, the stark contrast in infrastructural development between central and peripheral zones presents unequal working conditions. This makes Patna Urban Agglomeration an ideal case for examining how spatial inequalities in urban infrastructure affect women in uniformed public services. The study focuses on selected traffic points within PUA jurisdiction, ensuring a representative sample from both central (high-visibility) and peripheral (low-infrastructure) zones to analyse gendered disparities in workplace facilities.

Methodology

This study adopts a quantitative approach to assess disparities in workplace infrastructure available to women traffic police personnel in Patna Urban Agglomeration, Bihar. The objective is to examine whether significant differences exist in access to basic facilities, such as toilets, restrooms, shade areas, drinking water, first aid, and crèche services, based on their posting location (central vs. peripheral zones).

Data Collection

A structured, close-ended questionnaire was developed and administered to a purposive sample of **100 women traffic police personnel** posted across various traffic points in Patna Urban Agglomeration. The respondents were divided equally between the two zones:

- **Central Zone (n=50):** Typically includes high-density commercial and administrative areas. (Dak bungalow, boring road, Income tax, and Gandhi Maidan areas.)
- **Peripheral Zone (n = 50):** Covers outlying areas with lower administrative visibility and infrastructural investment. (Kankarbagh bypass, Saguna More, Danapur, and Phulwarisharif more.)

The questionnaire focused on facility availability, perceived adequacy, and related work challenges.

Data Analysis

The collected data were analysed using **Chi-square** tests to determine whether there were statistically significant associations between posting location and access to specific facilities. A significance level of **$p < 0.05$** was used to identify meaningful disparities. Microsoft Excel and SPSS were used for tabulation and computation.

The Chi-square test for independence was chosen for this study because the objective was to examine whether there is a statistically **significant association** between two categorical variables:

- **Location of deployment** (e.g., central vs. peripheral areas in Patna Urban Agglomeration), and
- **Availability of basic facilities** (e.g., toilets, restrooms, crèches – coded as Yes/No or Adequate/Inadequate).

This test is particularly suited when:

- The data is **non-parametric** (not based on an interval or ratio scale).
- The variables are **quantitative/categorical**.
- The sample size is reasonably large (n = 100 responses in this case).
- The goal is to **measure association**, not cause-and-effect relationships.

Unlike correlation or regression (which require continuous/numeric variables), or ANOVA (which compares means of continuous data across groups), the Chi-square test helps determine whether observed differences in facility access across spatial zones are due to chance or reflect a meaningful pattern.

For example, suppose a significantly higher proportion of women in peripheral zones report a lack of toilets compared to those in central zones. In that case, the Chi-square statistic will reflect this association, providing statistical backing to the argument of spatial gender disparity.

Limitations

The study is limited by its sample size and geographical focus on Patna urban agglomerations. However, it provides a useful picture of systemic gaps in gender-responsive urban infrastructure, laying the groundwork for broader comparative studies in other cities.

Statistical Analysis

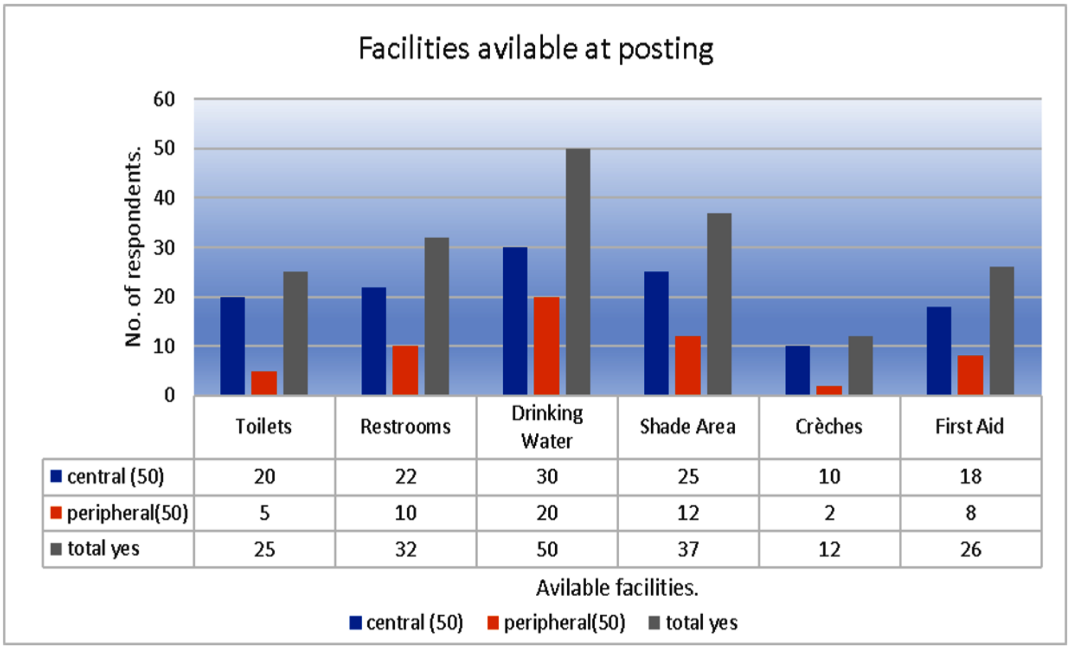
To analyse the facilities available for women in the traffic police, the following variables were taken and asked to 50 women in the core and peripheral areas.

- Restrooms
- Toilets (cleanliness, safety, availability)
- Drinking water
- Shade/rest areas
- Crèches for children
- Changing rooms
- First-aid and emergency support

Table 1 : Types of facilities available in selected areas.

Facility	Central (50)	Peripheral (50)	Total yes
Toilets	20	5	25
Restrooms	22	10	32
Drinking Water	30	20	50
Shade area	25	12	37
Creches	10	2	12
First aid	18	8	26

Source: *Based on field survey, 2024*



	Toilets	Restrooms	Drinking Water	Shade Area	Crèches	First Aid
central (50)	20	22	30	25	10	18
peripheral(50)	5	10	20	12	2	8
total yes	25	32	50	37	12	26

Figure 2: The availability of facilities in different posing areas

The bar diagram (Figure 2) and Table 3 present the availability of essential workplace facilities for women traffic police personnel in Patna Urban Agglomerations, based on a survey of 100 respondents. The analysis covers six critical amenities: toilets, restrooms, drinking water, shade/shelter, first aid kits, and crèche facilities.

The data reveals significant **infrastructural deficits** across most categories. Only 25 of the respondents reported access to clean and functional toilets at their duty posts, while resting areas or restrooms were available to just 32 respondents. Access to drinking water was slightly better, with 50 respondents reporting regular availability. Shade or shelter, crucial for personnel working in extreme weather conditions, was accessible to only 37 respondents.

Alarmingly, first aid kits were available to only 26 respondents in both locations, and crèche facilities—vital for working mothers—were available to 12 respondents. These findings highlight an **evident gap** between policy commitments toward gender-inclusive infrastructure and on-ground realities.

To find out the association between these facilities, a chi-square analysis of 100 responses was done, forming a null hypothesis; presented as follows: -

- Null Hypothesis (H_0): There is no association between posting location and toilet availability.

Table 2 : Availability of toilet facilities

Toilet Availability	Central Posting	Peripheral Posting	Total
Yes	20	5	25
No	30	45	75
Total	50	50	100

Source: *Based on field survey, 2025.*

Expected Values Calculation

Using the formula:

E = (Row Total × Column Total) / Grand Total

For example:

- Expected for (Yes, Central) = (25 × 50) / 100 = **12.5**
- Expected for (Yes, Peripheral) = (25 × 50) / 100 = **12.5**
- Expected for (No, Central) = (75 × 50) / 100 = **37.5**
- Expected for (No, Peripheral) = (75 × 50) / 100 = **37.5**

Chi-Square Formula = $\boldsymbol{x^2 = \sum \frac{(0-E)^2}{E}}$

Where O = Observed, E = Expected

Table 2 : Availability of toilet facilities at different postings.

cell	Observed data (no. of respondents)	Estimated data	(O−E)²/E
Yes, Central	20	12.5	$(7.5)^2 / 12.5 = 4.5$
Yes, Peripheral	5	12.5	$(-7.5)^2 / 12.5 = 4.5$
No, Central	30	37.5	$(-7.5)^2 / 37.5 = 1.5$
No, Peripheral	45	37.5	$(7.5)^2 / 37.5 = 1.5$

Source: *Based on field survey, 2024.*

Chi-square = 4.5 + 4.5 + 1.5 + 1.5 = **12.0**

Degrees of Freedom (df.) =(rows−1) ×(columns−1) = (2−1) (2−1) =1At df = 1, the critical value of χ^2 at 0.05 significance level = 3.84

Since **12.0 > 3.84**, the null hypothesis is rejected; it is concluded that there is a **statistically significant association** between posting location and access to toilets. Women posted in peripheral areas are **much less likely** to have toilet access.

The same Chi-square test is done to analyse other facilities like restrooms, drinking water, shade/rest areas, crèches, and first aid.

Table 3 : Chi-Square test for Restroom Availability

Restroom Availability	Central	Peripheral	Total
yes	22	10	32
no	28	40	68
total	50	50	100

Source: *Based on field survey, 2024*

Expected Yes (Central) = (32×50)/100 = 16

Expected Yes (Peripheral) = 16

Expected No (Central) = 34

Expected No (Peripheral) = 34

$$x^2 = \frac{(22-16)^2}{16} + \frac{(10-16)^2}{16} + \frac{(28-34)^2}{34} + \frac{(40-34)^2}{34} = 6.62$$

Critical value at degree of freedom = 1, α = 0.05 is 3.84

→ 6.62 > 3.84 = statistically significant

Conclusion: Restroom availability significantly varies by posting location.

The same calculation has been done for Drinking water, Creches, Shade area, and first aid.

Table 4: The final output of all the facilities available in the study area

Facility	**Chi-Square Value**	**Significant (p < 0.05)?**
Toilets	12.00	**yes**
Restrooms	6.62	**yes**
Drinking water	2.0	no
Shade area	5.4	**yes**
Creches	8.1	**yes**
First Aid	4.5	**yes**

Source: *Computed by the author based on the field survey, 2024.*

Results and Discussion

The Chi-square analysis (Table 4) reveals a statistically significant association between the posting location (central versus peripheral zones) and the availability of five out of six basic workplace facilities for women traffic police personnel in Patna Urban Agglomeration. These facilities include toilets, restrooms, shaded areas, crèche services, and first aid kits. Only the provision of drinking water did not demonstrate a statistically significant association with posting location. The findings offer convincing evidence of spatial inequality in infrastructure availability within the traffic policing system, disproportionately affecting women deployed in peripheral areas.

Among all facilities analysed, the availability of toilets exhibited the strongest statistical association with deployment zone. The data indicates that toilet facilities are far less accessible in peripheral areas compared to central zones. For female officers, especially those who are menstruating, pregnant, or suffering from health conditions, this lack of access has serious consequences. It not only compromises their physical health and hygiene but also contributes to psychological stress and diminished dignity in the workplace. The absence of such basic sanitation reflects a critical gap in gender-sensitive urban planning and calls for immediate infrastructural intervention.

Restroom access is another area of concern, significantly influenced by location. Women deployed in peripheral zones often work 8–12-hour shifts without access to a designated resting space. This lack of provision forces many to take breaks in unsuitable or even unsafe surroundings, contributing to fatigue, stress, and decreased performance. Adequate rest areas are essential not just for physical recuperation but also for mental well-being, especially in high-stress occupations like traffic management, which involves prolonged exposure to air pollution, heat, and continuous engagement with the public.

Similarly, the absence of shaded shelters at traffic posts disproportionately affects those in peripheral zones. In the intense heat of Patna's summers, lack of shelter exposes officers to risks such as sunburn, dehydration, and heatstroke. While male officers may also experience discomfort, women—particularly those in uniform designed without consideration for high temperatures—are more vulnerable. This structural oversight reflects deeper gender-blindness in occupational planning and infrastructure provisioning.

Crèche facilities, although largely inadequate across the board, show a significant gap favouring central postings. For women with small children, the availability of on-site or nearby crèche services directly influences their ability to work regular shifts without compromising on caregiving responsibilities. Lack of such facilities contributes to absenteeism, reduced career progression, and higher turnover, especially among younger or recently returning mothers.

The unavailability of first aid kits in peripheral areas poses a serious occupational hazard. Traffic police personnel routinely face physical risks, including accidents, heat-related fainting, and minor injuries. For women—who may already hesitate to report health concerns in a male-dominated environment—the absence of basic medical support further marginalizes their experience.

Interestingly, drinking water availability, though generally poor, did not vary significantly across zones. This suggests a baseline inadequacy in provisioning rather than spatial disparity. Still, uniform lack does not mitigate the concern—it highlights an overall neglect of officer welfare, requiring city-wide infrastructure audits and provisioning reforms.

Overall, these disparities reveal not just logistical shortcomings but institutional neglect of gender-sensitive planning. The concentration of basic facilities in central zones underscores a systemic prioritization of visibility over equity, leaving women in outer postings underserved and vulnerable. These findings underscore the need for targeted policy action to standardize workplace facilities across all traffic posts, integrating health, sanitation, and caregiving infrastructure as essential elements of workplace design for women in uniformed public service.

Conclusion

The statistical analysis of survey data from 100 women traffic police personnel in the Patna Urban Agglomeration reveals significant disparities in access to essential workplace facilities. Using the Chi-square test, it was examined whether posting location (central vs. peripheral) influenced the availability of various basic amenities.

The results show that access to toilets, restrooms, shade/rest areas, crèches, and first aid facilities is significantly associated with the posting location. In all these cases, women officers posted in peripheral areas reported substantially lower access to these critical services compared to their counterparts in central areas. The lack of crèche facilities was particularly stark, highlighting a major challenge for women with caregiving responsibilities. Although access to drinking water was relatively more uniform, the difference was not statistically significant. These findings underscore the urgent need for gender-sensitive urban infrastructure and policy interventions to support women in frontline public service roles. Ensuring equitable access to clean toilets, rest areas, drinking water, and childcare support is essential not only for the dignity and health of these women but also for improving their working conditions and job satisfaction.

Therefore, it is recommended that the PUA and the traffic police department take immediate steps to:

- Install mobile toilets and water stations in peripheral zones
- Develop rest shelters and shade areas at key intersections
- Establish or link to nearby crèche services for working mothers
- Regularly monitor and improve workplace facilities from a gender equity perspective

By addressing these inequities, Patna urban agglomerations and law enforcement agencies can improve working conditions, boost morale and productivity, and promote the long-term inclusion and retention of women in field-level policing roles. Such measures would not only enhance the working environment for women traffic police but also promote a more inclusive and responsive urban governance framework.

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SUSTAINABLE LIVELIHOODS IN FLOOD-PRONE SUPAUL DISTRICT: INTEGRATING FLOOD IMPACTS ON SOCIAL GROUPS AND MIGRATION PATTERNS

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ABSTRACT

This study investigates the dynamics of livelihood diversification and migration in Supaul district, Bihar, one of the most flood-prone regions of India. Drawing on primary household survey data from six villages, the analysis highlights how environmental stress, particularly recurrent floods from the Kosi River, interacts with socio-economic vulnerabilities such as land fragmentation, caste hierarchy and poverty to shape livelihood strategies. Findings reveal that non-farm income has become the dominant source of livelihood, contributing nearly 80% of household income, while agriculture and off-farm activities play a marginal role due to frequent flood-induced disruptions. Migration emerges as a central adaptive mechanism, with landless and marginal farming households—especially those belonging to Scheduled Castes and Extremely Backward Castes—showing the highest intensity of outmigration. Village-level disparities underscore the influence of infrastructure, market access, and social networks in enabling or constraining diversification opportunities. The study applies the Sustainable Livelihoods Framework to illustrate how diversification across farm, off-farm, and non-farm activities strengthens resilience, though unevenly across caste and landholding categories. It concludes by emphasizing the need for inclusive, climate-resilient livelihood strategies that combine skill development, rural infrastructure, and social protection to reduce vulnerability and enhance sustainability in Bihar's flood-prone rural economy.

Keywords : *Livelihood, environmental stress, Outmigration, Vulnerability*

Background

Supaul district, situated in the floodplains of North Bihar, is among India's most vulnerable agrarian regions. It lies in the Kosi River basin, an unstable fluvial system known as the *"Sorrow of Bihar"* for its frequent channel shifts, embankment breaches and devastating floods. Major disasters—such as the 2008 *Kusaha* embankment breach and recent high-discharge events in 2021 and 2024—have exposed the failure of structural flood management and the inadequacy of reactive relief efforts.

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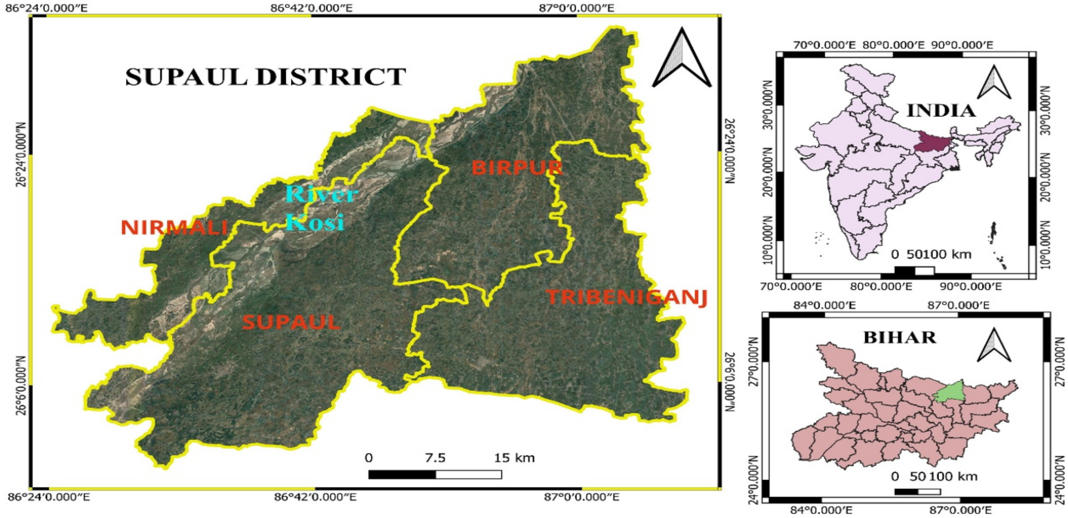
Over time, households have adapted by diversifying their income beyond subsistence farming into farm, off-farm and non-farm activities. This shift is driven by the need for economic stability amid environmental volatility, market constraints and repeated crop losses. Livelihoods now include wage labour, petty trade, seasonal migration and remittance-based income. These changes, however, are uneven and shaped by caste hierarchies, landholding size and market accessibility. Supaul has a high proportion of Scheduled Caste (SC) and Extremely Backward Caste (EBC) populations—often landless or marginal farmers—who bear the brunt of flood impacts and rely heavily on seasonal or circular migration (District Census Handbook 2011).

This study examines how recurrent flooding, coupled with socio-economic constraints, influences livelihood diversification in Supaul. It analyses income generation patterns across farm, off-farm and non-farm sectors, considering variables such as landholding size, caste identity, market access and migration. The role of caste in shaping access to resources, migration networks and income diversification is central, as are village-level differences in resilience determined by flood exposure and infrastructure. Ultimately, the aim is to propose inclusive, climate-resilient rural development strategies.

Significance of the Study

This research is significant because it addresses the intersection of environmental stress and socio-economic marginality in one of India's most hazard-prone districts. Supaul's situation mirrors broader challenges faced by rural South Asia—sustaining livelihoods amid climate change, agricultural decline and entrenched inequalities.



Source: *District Handbook*

Figure 1 : Location of Supaul District and its Physiographic setup

Despite heavy investment in flood control, large sections of the rural population—especially landless SC and EBC households—remain insecure, dependent on migration and low-paying non-farm work. With climate change likely to intensify hydrological hazards in the Ganga-Kosi basin, understanding and promoting diversified livelihood portfolios is urgent. By focusing on household-level data, the study reveals how vulnerable groups adapt to multiple stressors, how social divisions constrain access to opportunities and how migration operates both as a coping mechanism and as a development pathway.

Conceptual Framework

The study applies the Sustainable Livelihoods Framework (Ellis, 2000), which views income diversification as key to resilience. In Supaul's flood-prone setting, diversification is often a necessity rather than a choice. Livelihoods are grouped into:

- Farm-based – crop production, livestock, dairy, horticulture, fisheries; highly vulnerable to floods, especially for small/marginal farmers.
- Off-farm – activities linked to agriculture (threshing, milling, marketing, contract labour); essential during lean seasons or after crop loss.
- Non-farm – jobs unrelated to agriculture (shopkeeping, construction, transport, domestic work, government service, manufacturing), often available near towns or through migration.

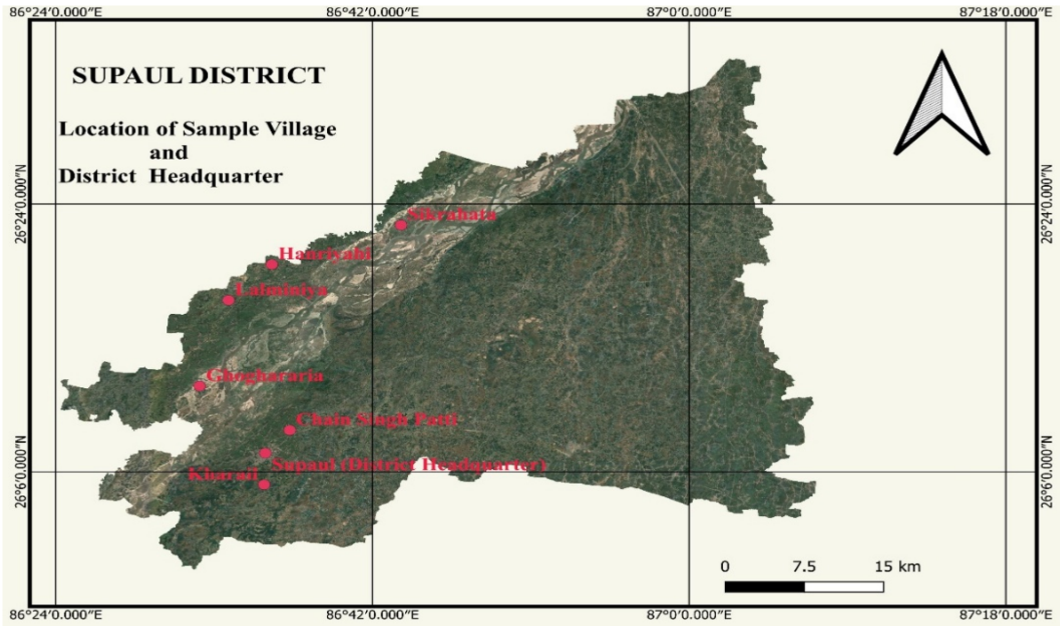
Structural factors—landholding, caste, flood risk, infrastructure and migration—shape these strategies. For example, recurrent floods reduce farm income, prompting shifts to non-farm work or migration; small land size limits productivity; and caste-based marginalization restricts access to credit, land and formal jobs. Migration serves both as a response to shocks and as a means to improve income and skills, with caste-based networks influencing who can migrate and benefit.

Literature Review

Development literature consistently links climatic risk, poverty and livelihood diversification. Theories of sustainable livelihoods (Ellis, 2000) and vulnerability stress that rural households diversify to reduce dependence on a single, risk-prone source of income like agriculture. In Supaul, floods disrupt cropping cycles, damage infrastructure and displace labour, making diversification critical. Diversification success depends on access to assets, skills and social networks (Barrett et al., 2001). Proximity to urban markets supports non-farm diversification (Briones, 2017). Migration is a common adaptation in flood-prone eastern India and Nepal (Datta, 2020; Roy, 2016), especially among economically weaker castes (Kundu & Das, 2022). Caste structures influence land ownership, credit access and occupational opportunities (Beteille, 1992; Kassegn & Abdinasir, 2023). SC and EBC households, often landless, rely heavily on wage labour and migration, while ST communities may face isolation despite land ownership. Spatial location—particularly market and infrastructure access—further determines diversification potential (Deichmann et al., 2009; Fafchamps & Shilpi, 2005). Policy recommendations emphasize integrated rural development—skills training, infrastructure, financial inclusion and social protection—to enable sustainable livelihoods (ILO, 2019; Kumar et al., 2012).

Scope of the Study

The research analyses the relationship between flooding, livelihood diversification and socio-economic structures in Supaul. It covers farm, off-farm and non-farm activities, considering caste, migration, market access and spatial location. Primary data from 365 households in six purposively selected villages captures diverse socio-economic and geographical contexts, from peri-urban to remote flood-prone areas. The study examines caste-wise livelihood patterns (SC, ST, BC, EBC, Others), migration types (intra-district, inter-district, inter-state, international) and livelihood combinations. The goal is to identify enabling factors and barriers and to propose targeted policy measures such as skill development, migration support and flood-resilient agriculture.



Source: *District Handbook*

Figure 2 : Location of Sample Village in Supaul District

Study Area Overview

Supaul lies between 25°37′–26°25′ N and 86°22′–87°10′ E, covering 2,420 sq. km in the eastern Gangetic plains. Bordered by Nepal (north), Madhubani (west), Araria (east) and Madhepura/Saharsa (south), it is dominated by flat alluvial terrain shaped by the Kosi River. The climate is humid subtropical, with hot summers, heavy monsoon rainfall (691–1,450 mm annually) and cool winters. Major crops include paddy, wheat, maize and sugarcane; floodplains also support grasses and aquatic vegetation like makhana (District Census Handbook 2011). As per the 2011 Census, the population was 2.23 million, 94% rural, with high density (919/sq. km) and low literacy (58.28%), especially among women. SCs form 14.87% and STs 0.20% of the population. Landlessness and marginal holdings dominate, especially among SC, EBC and OBC groups. Agriculture employs 76% of workers, with agricultural labourers comprising 43.39% and cultivators 32.56%. Social life is caste-structured and patriarchal, with Bhojpuri and Maithili as primary languages. Cultural life revolves around agrarian cycles, religious festivals and traditional crafts (District Census Handbook 2011).

Flood Problem in Supaul

Supaul is one of India's most flood-prone districts due to the Kosi River's heavy sediment load from the Himalayas and annual overflow. About 73% of Bihar's area is flood-affected, with Supaul facing some of the highest exposure. Catastrophic events—2008 *Kusaha* breach, 2021 floods and 2024 high discharge—have displaced thousands, destroyed homes and wiped out crops. (Sambal, 2020).

Flood impacts include prolonged waterlogging, disease outbreaks (e.g., 175 kala-azar cases in 2024) and infrastructure loss across hundreds of villages. Embankments, intended to control flooding, sometimes worsen it by restricting flow and causing breaches. Poor disaster management, cross-border delays with Nepal and stalled projects like the Dagmara barrage hamper mitigation. (Kansal *et al*., 2017; Down To Earth, 2024). Given the chronic nature of flooding, experts stress non-structural measures—floodplain zoning, improved early warning systems and resilient infrastructure—to complement livelihood-focused strategies. (India Today, 2024; The Economic Times, 2024b).

Database and Methodology

This study draws primarily on primary data collected through a structured household survey conducted in six purposively selected villages of Supaul district, Bihar—Karail, Chainsingh Patti, Sikrahata, Lalminiya, Harhiyahi and Ghoghararia. The selection of these villages was guided by the need to capture variation in flood exposure, proximity to urban centers and socio-economic diversity. A total of 365 households were surveyed using a detailed questionnaire designed to capture household demographics, landholding size, income-generating activities (farm, off-farm and non-farm), migration patterns (within-village, intra-district, inter-state and international), education levels, caste identity and flood-related experiences and coping strategies. Data collection was carried out through face-to-face interviews with household heads or senior family members to ensure both accuracy and contextual richness.

To complement the primary data, relevant secondary sources were reviewed. These included the *Census of India 2011* (District Census Handbook: Supaul) for demographic, occupational and literacy profiles; the *Bihar Statistical Handbook* (2020) for land use, irrigation, crop patterns and infrastructure; and reports from the District Disaster Management Authority (DDMA) Supaul, UNDP, ILO and the Government of Bihar addressing flood impacts, disaster risk reduction and livelihood resilience. Data entry, cleaning, data integrity checking, coding and statistical analysis were conducted using STATA 17. The software facilitated efficient data management, generation of descriptive statistics, cross-tabulation and correlation analysis, as well as the creation of graphical representations of key findings. Its command-based structure ensured the reproducibility and transparency of all analytical steps.

Results and Discussion

Against the backdrop of the 2011 Census, which reported an average household size of 5.5 in Supaul district (Census of India, 2011), the present survey reveals a slightly higher average of 5.67 members per rural household. The demographic composition is marked by a dominant working-age population (14–65 years), averaging 3.68 members per household, a figure substantially higher than that of children (0–14 years: mean 1.87) and the elderly (65+ years: mean 0.11). Although the prevalence of working-age adults suggests high labour potential and mobility, frequent out-migration often transfers the burden of care for children and the elderly to women and older residents, thereby reinforcing gendered vulnerability during flood events.

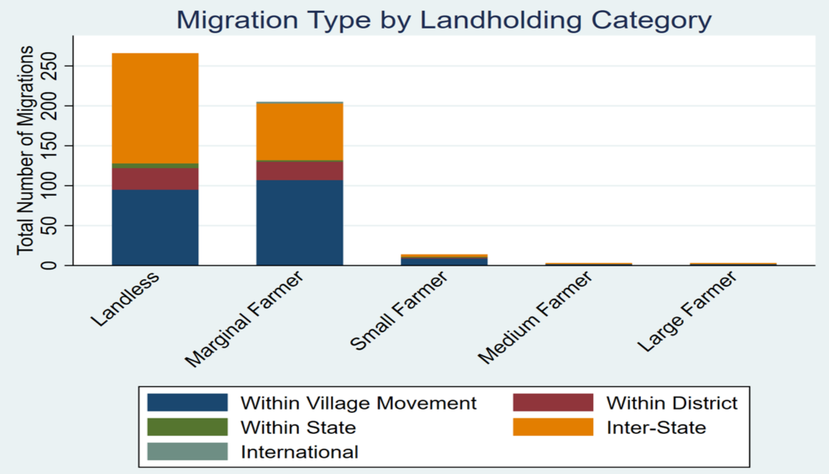
The economic profile of surveyed households reveals marked disparities. The mean monthly household income is ₹19,071, with a standard deviation of ₹14,232 and an income range stretching from ₹2,500 to ₹1,44,000. This substantial variation highlights persistent structural inequality, much of it shaped by uneven access to remittances from inter-state and international migration. Non-farm income emerges as the dominant livelihood source, averaging ₹15,776 per month and accounting for 79.65% of total household earnings, while farm income (₹1,908; 11.08%) and off-farm income (₹1,386; 9.27%) make notably smaller contributions. This departure from traditional agrarian dependence reflects a broader structural transformation driven by small, fragmented landholdings and recurrent flood-induced agricultural instability.

Village-level disparities further underscore the spatial dimensions of livelihood inequality. Karail and Chainsingh Patti, despite their proximity to the district centre, record the lowest average monthly incomes (₹17,187–₹17,356) and high internal inequality, as seen in Karail's substantial standard deviation (₹13,514). This pattern indicates that mere closeness to administrative or market hubs does not guarantee economic advantage without robust employment ecosystems and flood-resilient infrastructure.

By contrast, Sikrahata, Lalminiya and Harhiyahi display moderate income levels (₹18,426–₹19,075), possibly reflecting the benefits of better road connectivity and integration into semi-formal labour markets, which partially cushion the economic impact of environmental stress and support greater engagement in non-farm livelihoods. Ghogharaira, though remote, records the highest mean monthly income (₹23,478), yet its extremely high standard deviation (₹24,121) reveals significant income concentration within a few migrant-sending households. This suggests that remittance flows, while boosting average incomes, may simultaneously deepen intra-village inequality, particularly when migration opportunities are mediated by caste, kinship and access to established mobility networks.

Livelihood Diversification and Landholding

Livelihood diversification has emerged as a key strategy for rural economic adaptation in Supaul district, where frequent floods and small, fragmented landholdings limit the viability of agriculture as the sole source of income. With the average landholding size at just 1.51 acres, households have increasingly shifted toward non-farm income sources, which now account for 79.65% of total household income and 45.36% of households depend entirely on such activities.



Source: *Self Coumputed*

Figure 3 : Migration patter in household having different landholding

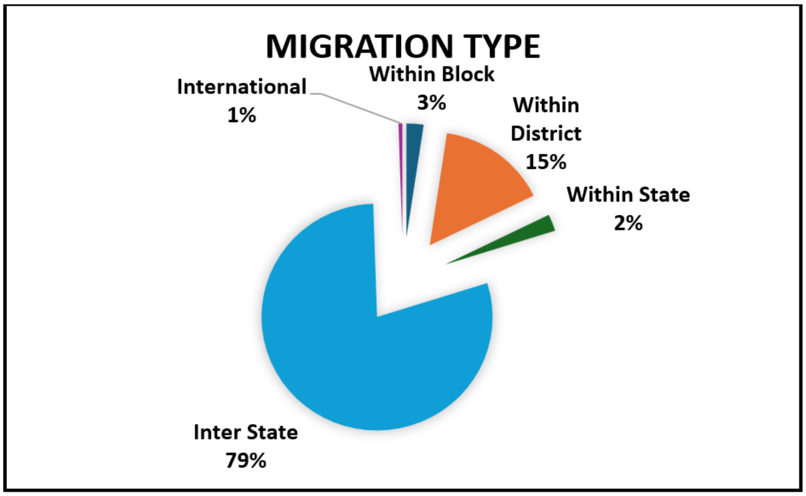
This transition marks a significant structural shift away from traditional farming toward livelihoods that are more resilient to environmental volatility. Patterns of diversification vary distinctly across landholding categories. Landless households, particularly flood-prone Scheduled Caste families, exhibit the highest reliance on non-farm income (89.52%) and record the largest number of migration events (133 total from 94 household), driven by recurrent crop failures and lack of productive land.

Marginal farmers, despite owning small plots, follow hybrid strategies—88.73% engage in both farm and non-farm work—and account for 282 migration events, with inter-state migration common among SC and BC groups as a means of supplementing limited agricultural income. Small farmers show a lower degree of diversification, with 55.56% involved in non-farm work and only 24 migration events, though floods still trigger selective outmigration, particularly among BC families. Medium and large farmers stand in contrast, relying entirely on non-farm income (100%) while recording minimal migration (6–8 events), a resilience largely derived from diversified entrepreneurial ventures, capital reserves and better access to education, credit and markets.

Migration as a Household Livelihood Strategy

Migration constitutes a central pillar in the livelihood strategies of rural households in Supaul, shaped by persistent environmental vulnerability and entrenched economic marginalization. Household survey data reveal a total of 377 migration instances across 365 households, underscoring the widespread dependence on mobility as both a coping mechanism and an adaptive response to livelihood insecurity. Notably, 94 households (25.75%) reported no long-distance migration; however, their members engaged in spatially limited labour movements within the same habitation—primarily for temporary agricultural or construction work.

Among the recorded migration events, interstate migration overwhelmingly dominates, accounting for nearly 80% of the total. This reflects the structural push of economic distress, recurrent crop failures and the pull of higher-paying employment in distant states such as Maharashtra, Punjab and Gujarat, where demand for low-skilled labour in construction, manufacturing and logistics remains high. These flows are predominantly cyclical or seasonal, often involving one or more household members at different times of the year.



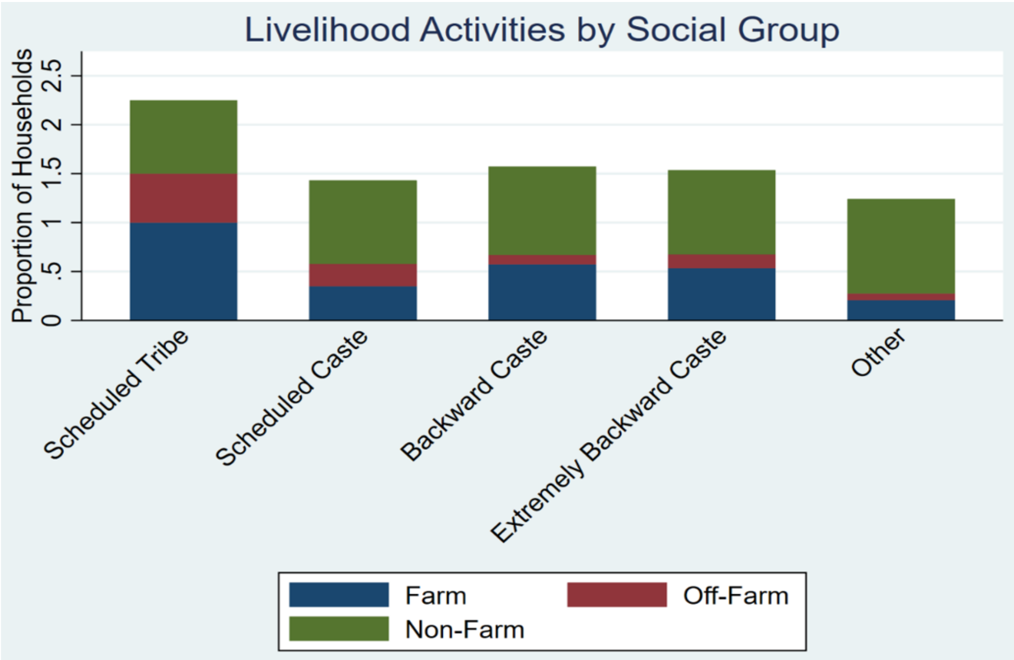
Source: *Self Computed*

Figure 4 : Migration pattern of sampled household

In contrast, within-district migration (15.89%, 58 individuals) and within-state migration (2.0%, 9 individuals) remain limited, pointing to the weak regional economic integration and low absorptive capacity of Bihar's local labour markets. International migration, though rare (0.55%, 2 individuals), contributes disproportionately to household income through high remittance inflows. Statistical analysis reinforces these patterns: a chi-square test ($\chi^2 = 2100$, df = 516, $p < 0.001$) confirms a highly significant association between migration type and causation, with job-seeking motives alone accounting for 68.4% of the 228 documented reasons for migration.

Flood Impacts on Migration by Social Group

Flood exposure emerges as a critical driver of migration in Supaul, affecting 53% of surveyed households (192 out of 365). The impact is particularly acute for households facing compound vulnerabilities, such as the combined effects of flooding and crop failure ($n = 10$), which record the highest migration intensity at an average of 2.8 migrants per household. This pattern underscores how environmental and economic stressors interact to precipitate mobility. However, migration responses are far from uniform, varying significantly across social groups in ways shaped by historical inequalities, asset distribution and embedded structural constraints. Scheduled Caste (SC) households, representing 93 out of 123 surveyed units, reported 133 total migrations—a high rate driven by landlessness and recurrent crop losses that force them toward both long-distance wage labour, such as construction and transport work in urban centres and informal local employment. This reliance on mobility is largely distress-led, reflecting exclusion from stable farm-based income sources.

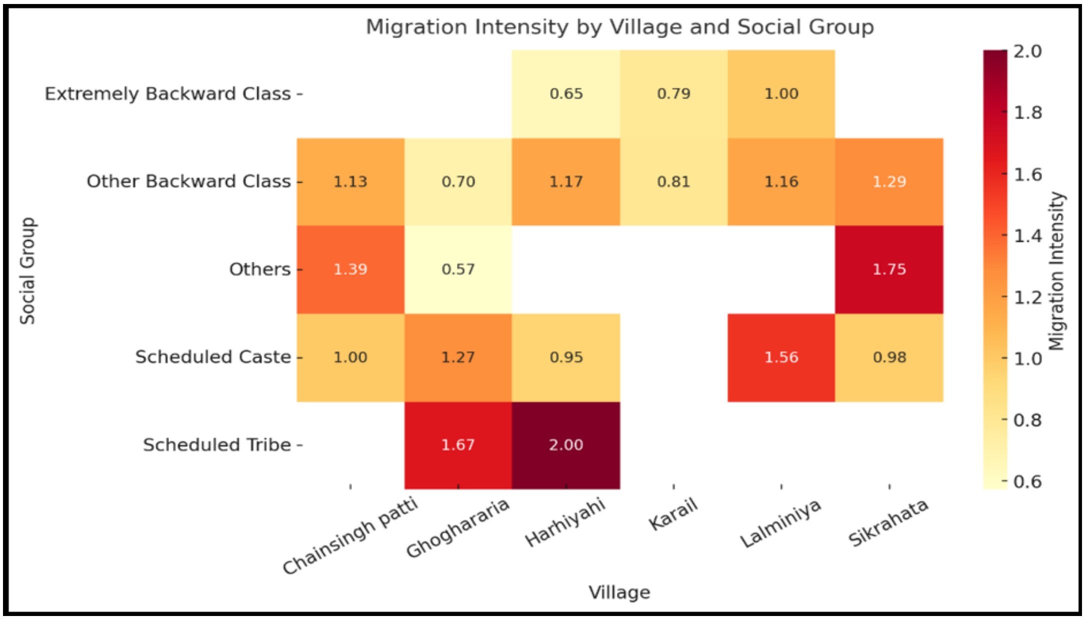


Source: *Self Computed*

Figure 5 : Livelihood Activities by Social Group.

Backward Caste (BC) households, the largest group in the sample with 166 families, recorded the highest overall migration volume (220 total movements). Their greater participation is linked to a more diverse livelihood portfolio, with 83 households combining farm and non-farm work and 61 depending solely on non-farm income. Better access to migration networks and moderate landholdings enables BC households to combine strategic interstate migration for wage-seeking with adaptive local movement during post-flood recovery periods.

Extremely Backward Caste (EBC) households (43 in total) showed moderate migration intensity, with 41 recorded movements, including 20 interstate cases. Despite comparable flood exposure, their limited mobility reflects restricted land assets and weaker social networks, which reduce opportunities for economic diversification and entry into remunerative migration streams. Scheduled Tribe (ST) households, the smallest and most geographically isolated group, reported the lowest migration levels—just seven movements, of which four were interstate. In contrast, households in the Others category (29 in total) demonstrated a more balanced migration profile, with 42 recorded movements, including 18 interstates. Their comparatively higher socio-economic position and occupational diversification buffer them from the immediate compulsion of distress migration, enabling them to pursue non-farm opportunities more strategically.



Source: *Self Computed*

Figure 6: Heat Map showing Migration intensity across Social groups in Sampled Village

Village-Level Spatial Variation in Migration Intensity

Migration intensity across Supaul's villages exhibits marked spatial differentiation, shaped by the combined influences of connectivity, environmental vulnerability and caste-mediated access to mobility networks. *Lalminiya* registers the highest overall migration intensity (1.22), followed closely by *Chainsingh Patti* (1.15) and *Sikrahata* (1.10), reflecting strong outflows relative to household numbers. In these well-connected villages, migration patterns diverge sharply by social group: in *Lalminiya, Scheduled Castes* (1.56) migrate most, indicating reliance on migration as a livelihood coping strategy among marginalised households. In contrast, Sikrahata's migration is dominated by socially advantaged *Others* (1.75), implying greater access to lucrative migration channels. *Chainsingh* Patti highlights the role of social capital, with *Others* (1.39) leading, followed by *OBC* (1.13) and *SC* (1.00).

At the other end, *Karail,* despite being close to the district headquarters, records the lowest intensity (0.80), suggesting either stronger dependence on local livelihoods or weaker migration networks. Remote and flood-prone settlements reveal more polarised outcomes. Harhiyahi reports very high migration among *Scheduled Tribes* (2.00) and *OBC* (1.17), but much lower rates for *EBC* (0.65) and moderate for *SC* (0.95), pointing to uneven migration access as an adaptation to environmental stress. Similarly, Ghoghararia has high migration for *SC* (1.27) and *ST* (1.67) but low for *OBC* (0.70) and *Others* (0.57), indicating that marginalised groups rely more heavily on migration when local opportunities are scarce.

Overall, migration intensity is not determined solely by geographic accessibility. It results from a complex interplay between location-specific economic opportunities, environmental pressures and caste-based social capital, producing distinct socio-spatial configurations of mobility. Well-connected villages (Chainsingh Patti, Lalminiya, Sikrahata) sustain moderate to high migration, though caste strongly shapes who participates most. Remote villages (Harhiyahi, Ghoghararia) display extreme contrasts—some groups migrate heavily under economic duress, while others remain mobility constrained. Market proximity alone does not guarantee high migration; instead, historical migration experience and social networks emerge as decisive factors.

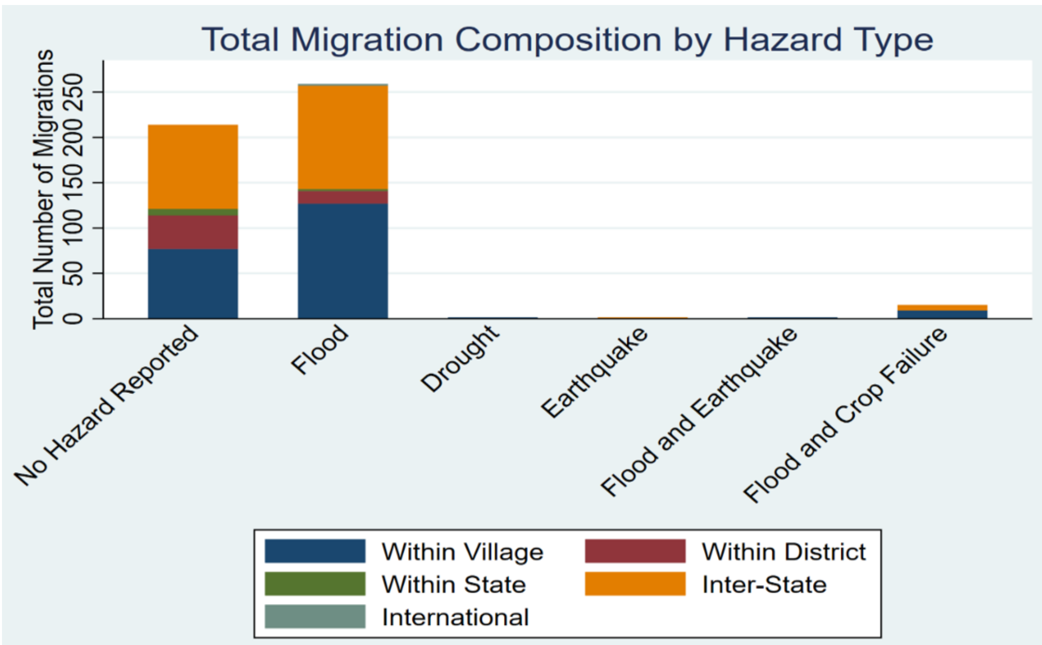
Hazard Exposure and Its Impact

In Supaul district, flooding stands out as the most significant environmental hazard, directly affecting 53% of surveyed households (192 out of 365). Of these, 49.59% experienced floods exclusively, while 2.74% faced compound vulnerabilities, such as simultaneous flooding and crop failure. These overlapping risks severely destabilize agriculture, erode household assets and drive migration, particularly among socio-economically marginalized groups like Scheduled Castes (SC) and Backward Castes (BC).

Flood-affected households account for nearly half (49.8%) of all recorded migrations in the survey, with those experiencing multiple hazards showing the highest migration intensity—averaging 2.8 migrants per household—indicating intensified adaptive pressure in the face of both environmental and economic insecurity. In contrast, non-hydrological hazards such as droughts and earthquakes were negligible, reported by only one household each, highlighting the need to prioritize flood risk management in policy and resource allocation. Notably, 46.85% of households reported no hazard exposure, which may be due to locational advantages like elevated terrain, embankment protection, or resilient infrastructure, though it could also reflect cognitive normalization of recurrent floods. In Supaul, floods act as both an acute push factor—triggering distress migration into local wage labour—and a chronic structural driver of strategic inter-state migration for income diversification and household stability through remittances. The interaction between environmental risk and social stratification determines migration patterns, destinations and adaptive capacity, underscoring the need for socially differentiated disaster responses, targeted flood adaptation strategies and resilient livelihood planning in flood-prone rural regions.

Flood Exposure and Migration Intensity: Village-Level Patterns

The village-level analysis of flood exposure and migration intensity highlights a nuanced and spatially varied relationship between environmental hazards and household mobility in the study area. Lalminiya records the highest migration intensity (1.22) despite only 45% of households reporting flood exposure, indicating that socio-economic advantages, better connectivity and strong migration networks are likely driving out-migration beyond hazard-induced pressures. Chainsingh Patti, with no reported flood exposure, still maintains a high migration intensity (1.15), reflecting a deeply rooted migration culture possibly tied to its proximity to markets and well-established employment links outside the village. In Sikrahata, high migration intensity (1.10) coincides with significant flood exposure (83%), suggesting that both environmental push and economic pull factors are shaping migration flows. Similarly, Harhiyahi and Ghoghararia display high flood exposure (84% and 82%, respectively) and identical migration intensities (0.97), but here migration appears primarily as a hazard-driven coping strategy, though possibly constrained by limited networks or resources. In contrast, Karail shows the lowest migration intensity (0.80) with negligible flood exposure (5%), likely due to its proximity to the district headquarters and better local livelihood options, reducing the need for migration.



Source: *Self Computed*

Figure 7 : Migration Composition by Hazard Types.

These patterns reveal that migration in flood-prone villages often serves as an adaptive response to environmental stress, while in less hazard-exposed or better-connected settlements, it is shaped more by structural economic opportunities and historical mobility linkages. Understanding this dual driver system is critical for designing targeted disaster risk reduction and livelihood strategies that address both the push of environmental stress and the pull of economic opportunity.

Migration by Livelihood Activity

This dataset reveals that migration intensity in the study villages is shaped by the complex interaction between spatial location, livelihood diversification and market connectivity. Villages with strong links to district towns, such as Lalminiya (1.22) and Sikrahata (1.10), exhibit high migration intensities despite having relatively diverse non-farm activities, suggesting that improved connectivity facilitates migration networks and access to external labour markets. Near-market villages present a mixed picture: Chainsingh Patti records high migration intensity (1.15) despite minimal crop diversification and heavy reliance on non-farm activities, indicating structural dependence on external income sources. In contrast, Karail, with substantial engagement in crop (30) and horticulture (16) activities, records the lowest migration intensity (0.80), reflecting stronger reliance on local agricultural livelihoods. Remote villages such as Harhiyahi and Ghoghararia show moderate migration intensities (0.97 each) alongside high engagement in crop and livestock rearing, suggesting that while environmental pressures such as flooding may trigger migration, diversified subsistence-oriented activities still provide partial livelihood security.

Overall, the spatial pattern indicates that connectivity and market access can both stimulate and reduce migration, depending on the strength of local livelihood options—particularly in agriculture and allied sectors. Proximity to markets can lower migration when agricultural incomes are stable (as in Karail) but may amplify it when local opportunities are insufficient to meet household aspirations (as in Chainsingh Patti). Well-connected villages to district towns, such as Lalminiya and Sikrahata, tend to experience higher migration because transport infrastructure reduces the transaction costs of mobility. Conversely, remote villages tend to rely on agricultural diversification and livestock rearing, using migration selectively as a complementary rather than primary livelihood strategy.

Table 1: Table chart comparing Location of village and Migration Intensity *vis-à-vis* occupation diversification

Village	Location	Migration Intensity	Crop diversification count	Livestock count	Fish count	Horticulture count	Off farm count	Nonfarm count
Chainsingh patti	Near Market	1.15	4	5	0	1	11	52
Karail	Near Market	0.80	30	26	4	16	9	49
Lalminiya	Well Connected with District Town	1.22	24	26	0	7	3	58
Sikrahata	Well Connected with District Town	1.10	26	23	0	2	13	53
Ghoghararia	Remote Location	0.97	29	33	1	3	11	55
Harhiyahi	Remote Location	0.97	35	32	0	12	8	56
Total			**148**	**145**	**5**	**41**	**55**	**323**

Source: *Self Computed*

Spatial Distribution of Livelihood Activities

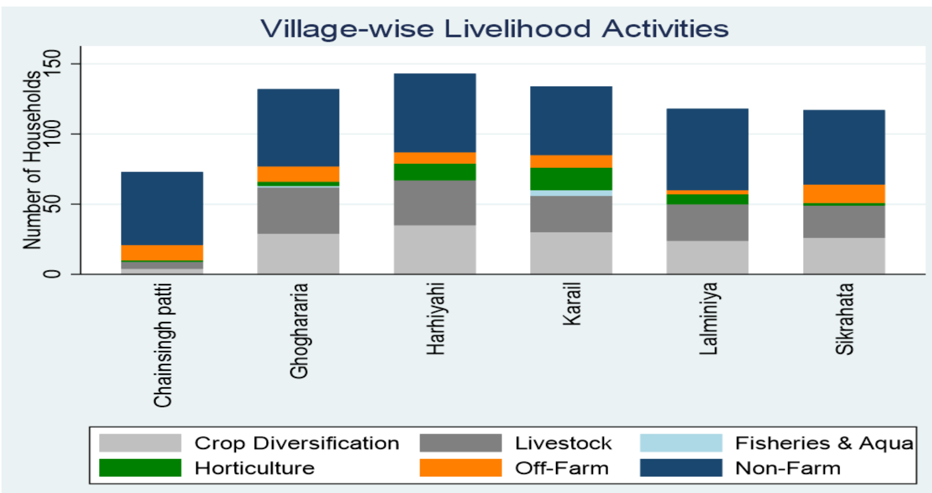
The spatial distribution of livelihood activities across villages reveals clear patterns of sectoral dependence, with notable implications for migration behaviour and economic resilience. Non-farm activities dominate the economic landscape, accounting for 323 out of the 548 recorded engagements (58.94%), signalling a structural shift away from agriculture as the primary source of livelihood. Chainsingh Patti (72 households) and Lalminiya (88) record the highest proportion of non-farm participation, with 52 and 58 households respectively engaged in such activities. This trend is likely driven by better connectivity to markets and access to diversified employment opportunities, which reduces reliance on agriculture but may also correlate with higher migration intensity as households pursue better-paying work.

Farm-based activities, involving 171 households (31.21%), show a more uneven distribution, with Harhiyahi (39 households) and Ghoghararia (37) emerging as key agricultural hubs. Both are relatively remote and flood-prone, where farming remains essential despite the risks. In contrast, Chainsingh Patti has only 9 farming households, reflecting its strong non-farm orientation and market-linked economy. Off-farm activities—mainly agricultural wage labour—are undertaken by 54 households (9.85%) and display a relatively even spread, peaking in Sikrahata (13 households) and Chainsingh Patti (11 households). These locations appear to combine seasonal agricultural employment with non-farm earnings, indicating a mixed economic base.

Spatially, villages close to district markets such as Chainsingh Patti and Karail show high non-farm dependency and lower agricultural engagement, pointing to stronger integration into trade and service networks. Similarly, district-linked but moderately distant villages like Lalminiya and Sikrahata maintain diversified livelihoods but still lean toward non-farm dominance. Conversely, remote settlements such as Harhiyahi and Ghoghararia sustain higher agricultural dependence while simultaneously expanding non-farm activities, reflecting adaptive diversification under environmental stress. Overall, the evidence highlights that proximity to markets and transport infrastructure pushes livelihoods toward non-farm sectors, whereas remote and hazard-prone areas retain a stronger agricultural base but increasingly incorporate non-farm work as a strategy for coping and income enhancement.

Migration and Occupational Diversification at the Village Level

The relationship between migration and occupational diversification at the village level reveals a clear and consistent pattern: households engaged in multi-sectoral activities, particularly those that include non-farm work, tend to have higher migration levels compared to households dependent on a single livelihood type. Villages such as Lalminiya (73 total migrants) and Chainsingh Patti (69 migrants) stand out for their high migration counts, largely driven by households involved in Non-farm only activities (31 and 43 households, respectively) and Farm and Non-farm combinations (25 and 6 households). This trend suggests that non-farm-oriented households either migrate to access better-paying employment opportunities or take advantage of established migration networks linked to urban labour markets.



Source: *Self Computed*

Figure 8 : Livelihood Composition in sampled village

Smaller groups such as Off-farm + Non-farm and Farm + Off-farm + Non-farm, despite their limited absolute numbers, tend to record disproportionately high migration rates. For example, Sikrahata has only three households in the Farm + Off-farm + Non-farm category, yet all have at least one migrant, indicating a 100% migration intensity.

Spatial factors also shape these trends: villages with better market access and connectivity, such as Lalminiya and Sikrahata, show a combination of higher occupational diversity and elevated migration levels, whereas more remote settlements like Harhiyahi and Ghoghararia exhibit migration concentrated in a few diversified households, often within specific combinations such as Farm + Non-farm. Overall, the evidence indicates that occupational diversification—particularly into non-farm sectors—is a significant facilitator of migration, while farm-only dependence tends to keep households locally rooted. These effects, however, are mediated by geographic location, infrastructural access and the strength of existing migration networks.

Conclusion

In conclusion, the analysis demonstrates that migration at the village level is strongly influenced by the extent and nature of occupational diversification. Households engaged in non-farm activities—whether exclusively or in combination with farm and off-farm work—tend to record the highest migration rates, indicating that diversification into non-farm sectors enhances mobility by opening access to urban labour markets and established migration networks. In contrast, farm-only households exhibit low migration intensity, reflecting a stronger attachment to local agrarian livelihoods and possible reliance on land-based subsistence. The data also highlight that multi-sectoral households, particularly those combining off-farm and non-farm work, often display disproportionately high migration levels, even when their absolute numbers are small.

Spatial factors further shape these dynamics: villages with better market access and infrastructure, such as Lalminiya and Sikrahata, show both higher occupational diversity and elevated migration rates, while remote villages like Harhiyahi and Ghoghararia exhibit more localized and selective migration patterns. Overall, occupational diversification—especially toward non-farm employment—emerges as a significant driver of migration, with its impact reinforced or constrained by spatial connectivity and existing social-migration networks. To achieve sustainable livelihood, the promotion of non-farm employment in rural regions necessitates the development of micro-entrepreneurship initiatives underpinned by targeted skill development programs and accessible microfinance, adapted to the unique socio-economic and geographic characteristics of the area. However, findings from the field survey indicate a paucity of reliable and measurable variables capable of capturing the influence of skill training on non-farm occupational diversification. This gap underscores the need for further empirical investigation to assess and quantify the relationship between skill development interventions and rural non-farm employment outcomes.

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PDS COVERAGE IN BIHAR : EVIDENCES FROM DOCUMENTS

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ABSTRACT

Out of the basic needs of human beings, the most important one is food. So much so that assuring food security to all has been taken as one of the sustainable development goals. There are four major components of food security according to FAO, viz, availability of food, accessibility of food, stability of food supply and its utilization. In a country with a large population like India, assuring food security is a major challenge. The country ranked 111th out of 121 countries in the Global Hunger Index in 2023. In densely populated and underdeveloped states of the country such as Bihar, the achievement of food security is crucial. The Public Distribution System (PDS) plays an important role in this direction. Bihar ranked eighth in the state ranking index for NFSA in 2022 in the comprehensive country level index. In Bihar the PDS issues the Priority Household ration cards and the Antyodaya Anna Yojana ration cards. This paper aims to present a regional coverage study of PDS in Bihar. The paper is based on secondary data. Suitable cartographic techniques have been used to analyze and portray the data and outline the conclusions.

Keywords : *Antyodaya Anna Yojana, Food security, Priority Household, Public distribution system*

Introduction

Food, clothing, shelter, access to medical facilities and education are the basic needs of mankind. Amongst these, food is the most important as without it, survival of life is impossible. Its importance is accepted throughout the world which is depicted in the fact that achieving zero hunger, in other words assuring and achieving food security for all by 2030 has been taken as one of the sustainable development goals (Rickards & Shortis, 2019). In a country with a large population like India, assuring food security is a major challenge. The country ranked 111th out of 121 countries in the Global Hunger Index (2023). The Public

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Distribution System is an important intervention in addressing this challenge in India (George & McKay, 2019). The Public Distribution System is a system of managing the food scarcity by distributing food grains at an affordable and subsidized rate to the needy sections of the society through Fair Price Shops, also known as ration shops (National Food Security Portal, n.d.). It is supplementary in nature and does not intend to make available the entire requirement of any of the commodities distributed under it to a household or a section of the society and is operated under the joint responsibility of the Central and state / UT Governments (Ibid). The process of procurement, storage, transportation and bulk allocation of food grains in undertaken by the central government through the Food Corporation of India (FCI) while its operational responsibility including allocation within state, identification of eligible families, issuing of ration cards and supervision of the functioning of Fair Price Shops is the responsibility of the state / UT Government (Balani, 2013).

In densely populated and underdeveloped administrative units like Bihar, the achievement of food security is crucial and increased efficiency of the Public Distribution System (PDS) is imperative to achieve this end.

However, Khera (2011a; 2011b) classifies Bihar as a languishing state in the domain of the Public Distribution System. Several studies have been done in this area focusing on Bihar in recent years. Dutta (2012) has worked on the Public Distribution System of Bihar where it is highlighted that Bihar happens to the poorest and yet has hardly been benefited from the Public Distribution System. In 2008, the per capita PDS foodgrain was as low as 9.5 kg per capita (Dutta, 2012). More recent studies like Kumar et al. (2016), Kumari et al., (2023) and Jha (2024) have shed new light on PDS in Bihar.

Kumar et al. (2016) combined NSS data and microlevel insights at the Village Level in Bihar to show that there was a positive turn in the functioning of PDS of the state. Kumari et al. (2023) study the distribution pattern of Antyodaya Anna Yojana (AAH) and Priority House Holders (PHH) Cards to understand the extent of the development of PDS in Bihar. Their findings are more focused towards identifying which of the two programs is better accessed by the locals and in which region of the state rather than on the food security question related to PDS. Jha (2024) has used the Service Quality (SERVQUAL) model to measure satisfaction of the end beneficiaries with the Aadhar enabled public distribution system (AePDS) to determine the effectiveness of AePDS in Forbesganj Block of Araria District, Bihar. This shows that after

2016, the studies on PDS in Bihar have focused more on the PDS programs rather than the actual distribution.

Therefore, it becomes crucial to study the PDS of Bihar and to question whether the efficiency and coverage of the Public Distribution System in Bihar have improved or not, and to what extent.

Research Questions: Therefore, the following research questions (RQs) become relevant for this study:

RQ1: Is the coverage of Public Distribution System in Bihar uniform across all districts?

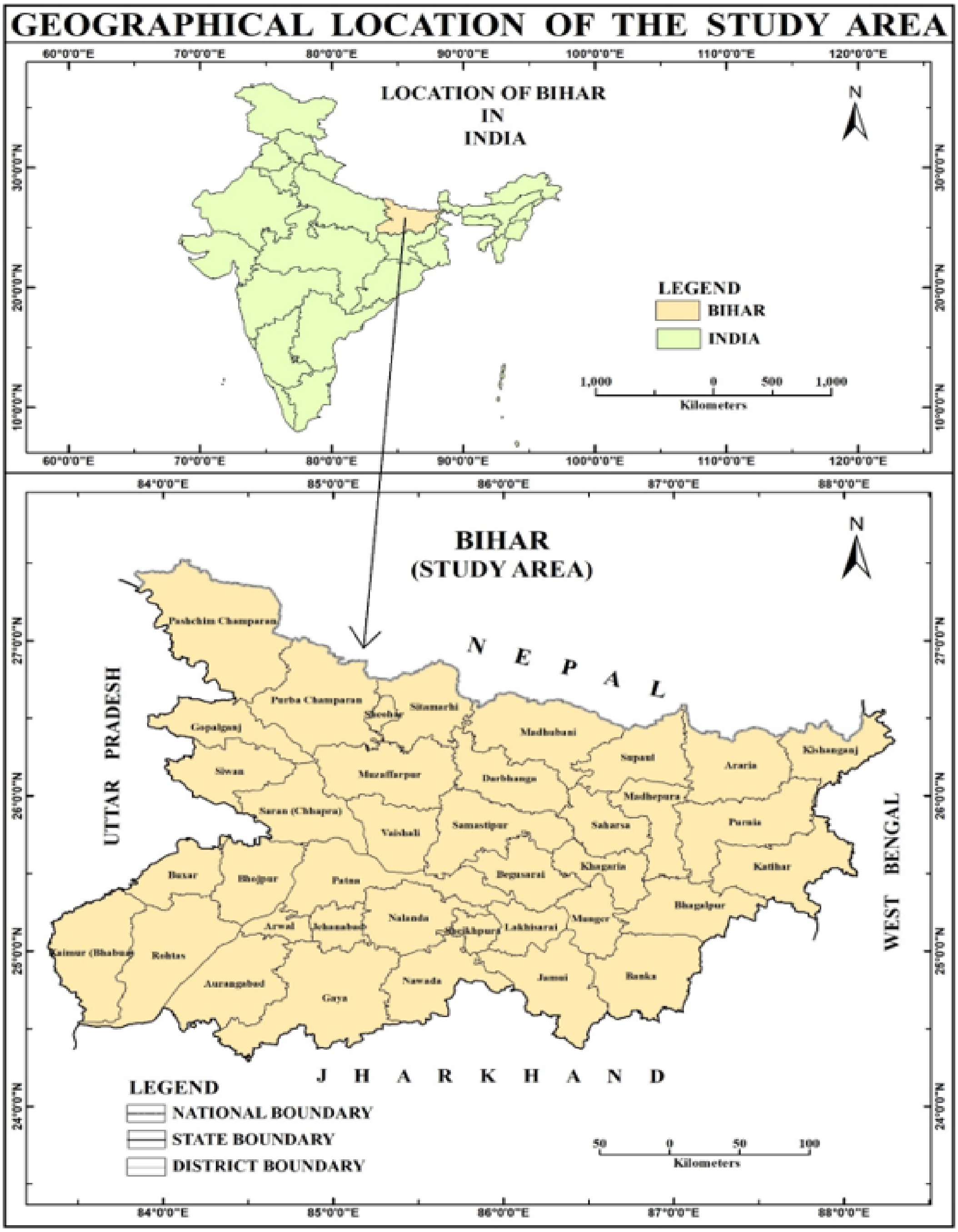
RQ2: Is the coverage of Public Distribution System in Bihar adequate?

Objective

The present paper aims to present a spatial distribution of Public Distribution System in Bihar at district level to present a picture of the state of Public Distribution System within the state along with its coverage, and its development across districts. This would aid the policy makers to take adequate action to facilitate the growth and coverage of Public Distribution System in Bihar.

Study Area

Located in east India, the state of Bihar covers an area of 94,163 sq.km and extends from 24^{0}20'10" N to 27^{0}31'15" N latitude and 83^{0}19'50" E to 88^{0}17'40" E longitude (Census of India, 2011). It is bordered by Uttar Pradesh in the west, Jharkhand in the south, West Bengal in the east and Nepal in the north. The mighty river Ganga traverses the state through its middle and divides it into two parts – North Bihar and South Bihar. While North Bihar is a flood prone area South Bihar is drought prone. The state constitutes of 38 districts. In the census of 2011, the state of Bihar recorded a total population of 18,867,444 persons and was the fourth most populous state in the country. However, it emerged as the most densely populated state in the country with a density of 1106 persons per sq. km. It recorded an average literacy rate of 61.8% which was lowest amongst the states of India. The sex ratio was 918 females per thousand males. 15.91 % of the state's population comprised of scheduled caste. The work participation rate was recorded as 33.36%. (Census of India, 2011)



Source: *Prepared by author.*

Figure 1: Geographical location of the study area

Methodology

The present paper is based on secondary data obtained from the official website of Food and Consumer Protection Department, Government of Bihar. The data showing the growth of PDS has been taken from the annavitran abstract for the month of August for the years 2020 to 2024. The data regarding the regional distribution of PDS and the sale of commodities is from the monthly report of August 2024. The data has been represented with suitable cartographic techniques like pie chart , multiple bar diagram, and divided bar diagram. The descriptive analysis of the data has also been done. This is shown in Figure 3. Proportionate pie diagrams have been used in Figure 5.

Nelson method has been used for mapping the distribution of NFSA ration cards that shows the coverage of the Public Distribution System in the state. This method uses standard deviation to classify diversity of different regions and sub-zones based on a certain variable, say population density.

The advantage of Nelson's method is that it is a flexible method that is not limited by demographic data or urban development data, where it is most commonly used. Since this method recognizes that a city may have more than one specialization, the policy makers can make appropriate policies for the city's development or industrial growth. For example, researchers have used it to study spatial variations in Gross Domestic Product (Nelson, 1955).

Another benefit of this method is that it can provide exhaustive information regarding spatial variations depending upon the data available.

Following this method, standard deviations from mean for the variable were calculated and six degrees of variances were recognized aiding in the classification of districts according to the NFSA ration cards in Bihar. The details are described in results section.

History of Public Distribution System in India: The Public Distribution System (PDS) in India, as we understand it today, primarily developed in the 20th century. However, it has a long and evolving history in India. Medieval India had various mechanisms for food distribution and management resources that can been seen as precursors to modern PDS such as maintenance of royal granaries and storage by the rulers which stored surplus grain which could be used in times of famine, regulation of market by fixing prices of essential commodities to prevent hoarding and exploitation, temple granaries which made 'annadan' to the needy, particularly during festivals and droughts and famines, revenue collection and its redistribution to support the poor. The merchants and trade guilds often facilitated the distribution of food and essential goods, ensuring that communities had access to them. While not a formalised system like the contemporary PDS, these practices in medieval India reflect a recognition of the importance of food security and welfare for the populace. The mechanism of storage, regulation and distribution laid the groundwork for more organised system of Public Distribution in later times. The first glimpses of the Public Distribution in India in the 20th century were seen during the Second World War when the food shortages during the war prompted the Government to establish the first rationing system to control the distribution of essential commodities. Post Independence, i.e. after 1947, the need for a structure food distribution system became evident due to widespread poverty and hunger (Pal, 2011). The PDS was formally established in the 1960's with the objective of providing essential food items during food shortages and crisis with particular focus on the dissemination and allocation of foodgrains in areas of scarcity. The remarkable increase in food production during the first phase of Green Revolution (1960s to 1970s) led to further extension of the Public Distribution System during the following two decades. In June 1992, the Revamped Public Distribution System (RPDS) was launched by the Government with a view to strengthen and streamline the PDS and increase its coverage. Under the RPDS, 1775 blocks in areas where special development programmes were running such as Drought Prone Area Programme (DPAP). Integrated Tribal Development Projects (ITDP), Desert Development Programme (DDP) and certain Designated Hill Areas were identified for special focus (nfsa.gov.in). In June 1997 the Targeted Public Distribution System was introduced by the Government, aimed at identifying and assisting the BPL sections of the society. The Planning Commission's State-wise poverty estimates for 1993–1994 were used by the States to identify the poor under the program. These estimates were based on the methodology of the "Expert Group on estimation of proportion and number of poor," which was chaired by the late Prof. Lakdawala. At the time of the TPDS's implementation, the distribution of food grains among the States and UTs was determined by the average yearly off-take of food grains under the PDS over the previous ten years (nfsa.gov.in & Bhattacharya, Falcao & Puri, 2017). In 1997 the Antyoday Anna Yojana (AAY) was launched to provide food security to the poorest segment of the BPL population. A landmark legislation with reference to PDS in India was the National Food Security Act (NFSA),2013 which aimed to provide legal entitlement to subsidized food grains, expanding coverage to approximately two-thirds of India's population. Technology has been introduced in recent years to improve the efficiency and transparency of the distribution process, including biometric systems and online applications.

Analysis and Discussion

Public Distribution System in Bihar: Under the NFSA, 2013 two types of Public Distribution System Ration Cards are being issued in Bihar, viz. the AAY cards and the PHH cards.

Antyoday Anna Yojana Card: This type of ration card is given to poor families who do not have a stable income as identified by the state government. The following criteria are used in order to identify these households:

a) Slum dwellers, marginal farmers, landless agricultural labourers, rural artisans and craftsmen like potters, tanners, weavers, blacksmiths, carpenters, and people who make a living on a daily basis in the unorganised sector like porters, coolies, rickshaw pullers, hand cart pullers, fruit and flower vendors, snake charmers, rag pickers, cobblers, destitute, and other similar groups in both rural and urban areas (National Food Security Portal, n.d.).

b) Families with widows, terminally sick, disabled, or older individuals (60 years or older) who lack a reliable source of income or social assistance (Ibid).

c) Widows, people with terminal illnesses, people with disabilities, people 60 years of age or more, and women or men who are alone and lack family or social support (Ibid).

d) All primitive tribal households (Ibid).

The AAY card holders are eligible to receive 35 kg of food grains per month per family (15 kgs of wheat and 20 kgs of rice) at the subsidized price of Rs. 2 per Kg for wheat and Rs. 3 per kg for rice. (National Food Security Portal, n.d.)

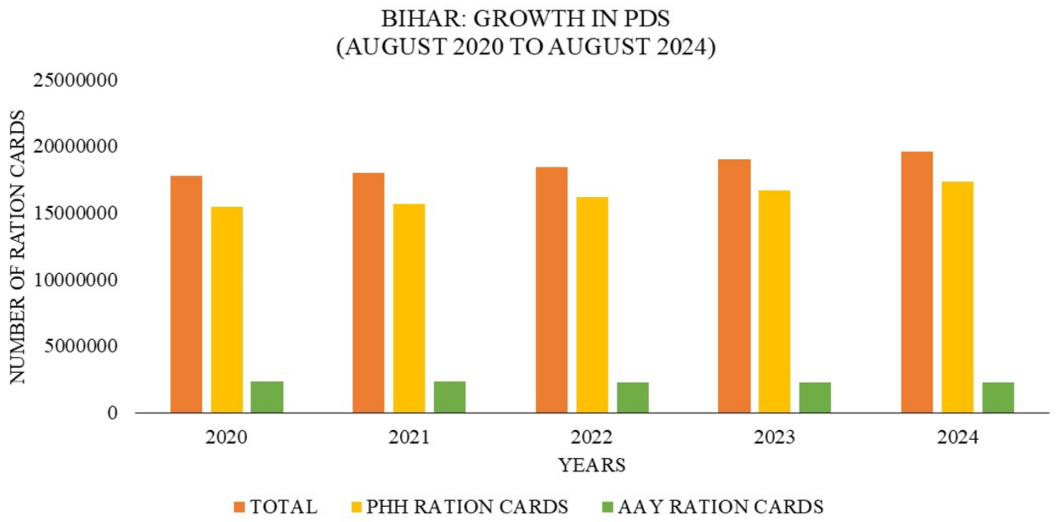
Priority Household (PHH) card: PHH applies to families that are not covered by AAY. The PHH families are identified by the state government under the Targeted Public Distribution System according to its guidelines for inclusion and exclusion. The PHH card holders receive 5 kgs of food grains per person per month at a subsidized price of Rs. 2 per Kg for wheat and Rs. 3 per kg for rice and Rs. 1 per kg for coarse grains. (nfsa.gov.in)

Growth Status of Public Distribution System at State Level (August 2020 to August 2024): The PDS in Bihar has shown a negligible growth during the last five year (Table 1). Though the number of Fair Price Shops have increased from 48927 in the year 2020 to 54487 in the year 2024, the percentage growth in their numbers is just 0.11 which is not at all significant. Similarly, though the number of NFSA ration cards has witnessed an increase from 17813511 in 2020 to 19614745 in August 2024, this increase is merely of 0.10%. Bulk of the ration cards have been issues under the Priority Household Scheme and this trend has continued from 2020 to 2024 (Table 1, Figure 1). In fact, the proportion of PHH ration cards has slightly increased during the reference period. In 2020, 86.63% of the ration cards issued were under the PHH Scheme while in 2024 their percentage has increased to 88.33.

Table 1 : Bihar: Growth of PDS (August 2020 to August 2024)

Year	No. of FPS	NFSA Ration Cards				
		Total	PHH Ration Cards	% of PHH Ration Cards	AAY Ration Cards	% of AAY Ration Cards
2020	48927	17813511	15433046	86.63	2380465	13.36
2021	51445	17983391	15670767	87.14	2312624	12.85
2022	52455	18464339	16171265	87.58	2293074	12.41
2023	53550	19023479	16729276	87.94	2294203	12.05
2024	54487	19614745	17325943	88.33	2288802	11.06

Source: *Annavitran Abstract for the month of August, 2020, 2021, 2022, 2023 & 2024 (AePDS, Food and Consumer Protection Department, Government of Bihar)*



Source: *Author's own based on Table 1*

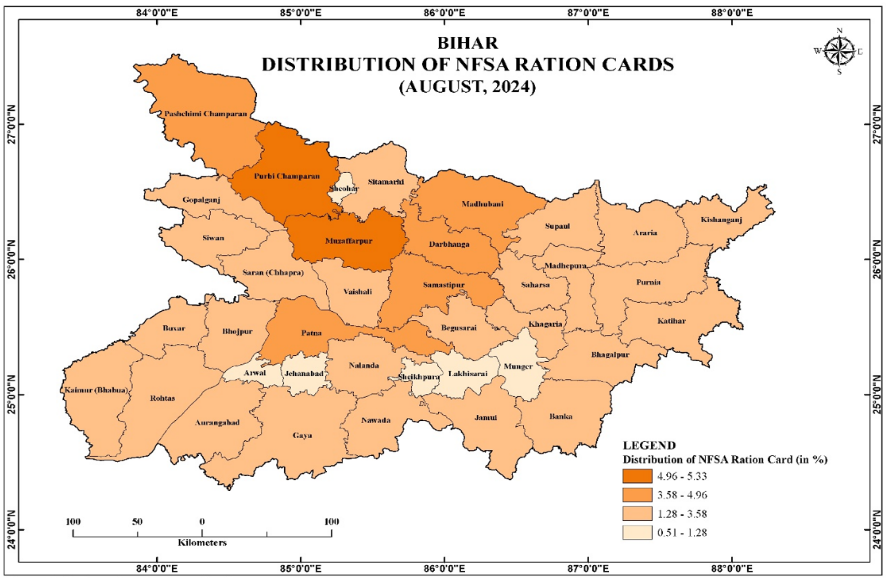
Figure 2: Growth of PDS in Bihar

Regional Variability in Public Distribution System in Bihar: By August 2024 a total of 18067039 ration cards were issued in the state of Bihar under the Public Distribution System. There is district level variation in the number of cards issued (Appendix I). Maximum number of ration cards of the total issued in the state were issued in Muzaffarpur district (5.46%) followed by Patna district (5.05%). Minimum number of ration cards were issued in the districts of Arwal (0.52%) and Sheikhpura (0.53%). The districts can be grouped into four categories based on the distribution of total ration cards in Bihar -

(a) Districts accounting for less than 1.36% of the issued NFSA Ration Cards- Arwal, Sheikhpura, Lakhisarai, Sheohar, Munger and Jehanabad come under this group.

(b) Districts accounting for 1.36%-3.87% of the issued NFSA Ration Cards - Districts of Buxar, Kaimur, Jamui, Khagaria, Nawada, Kishanganj, Aurangabad, Madhepura, Banka, Saharsa, Gopalganj, Bhojpur, Rohtas, Supaul, Vaishali, Nalanda, Begusarai, Bhagalpur, Saran, Siwan, Araria, Purnea, Katihar, Sitamarhi and Gaya come under this group. Twenty-five out of the thirty-eight districts of the state lie within this group.

(c) Districts accounting for 3.87%-5.12% of the issued NFSA Ration Cards – Paschimn Champaran, Madhubani, Darbhanga, Patna, Samastipur and Purba Champaran fall under this category.

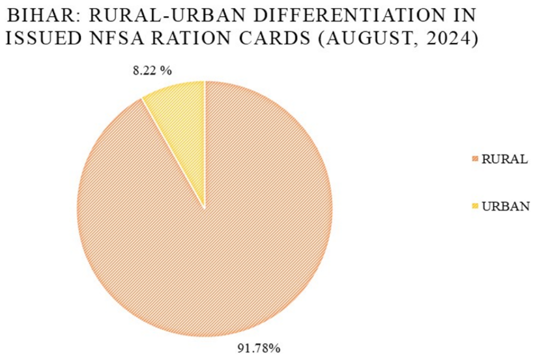


Source: *Compiled by Authors*

Figure 3: Distribution of NFSA ration cards in Bihar

(d) Districts accounting for more than 5.12% of the issued NFSA Ration Cards – It includes Muzaffarpur.

Rural-Urban Variability in Public Distribution System in Bihar: There is a marked rural-urban variability in the distribution of NFSA ration cards in Bihar. Out of the total ration cards issued in the state by August 2024, 91.78% were issued in the rural areas and only 8.22% were issued in urban areas. This clearly indicates that the coverage of PDS is more in the rural areas of the state. The same trend is observed within the districts of the state. In all the districts more than 80% of the NFSA ration cards issued have been issued in rural areas. The only exception to the case is Patna district where 65.55% issued ration cards are in rural areas and 34.45% have been issued in urban areas. This is because it is the most urbanised district of the state.



Source: Author's own based on calculation from Monthly Report of Food and Consumer Protection Department, Government of Bihar, August, 2024

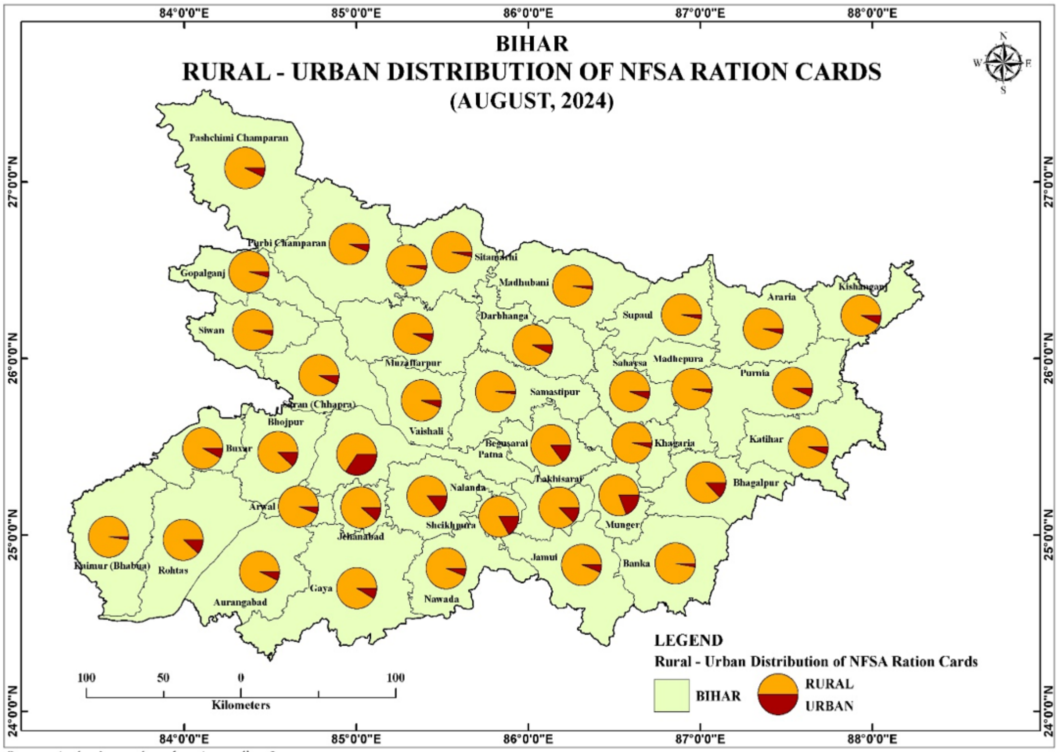
Figure 4: Rural-urban Differentiation in issued NFSA ration cards

Based on the proportion of rural ration cards issued, we can categorise the districts into four broad categories (excluding Patna), viz. (Appendix 1)

(a) Districts where 80%-85% of the issued ration cards are in rural areas – Munger and Sheikhpura

(b) Districts where 85%-90% of the issued ration cards are in rural areas – Begusarai, Bhagalpur, Lakhisarai, Nalanda, Bhojpur, Rohtas and Jehanabad

(c) Districts where 90%-95% of the issued ration cards are in rural areas - 16 districts fall under this category namely Paschim Champaran, Purba Champaran, Kishanganj, Purnea, Katihar, Saharsa, Darbhanga, Muzaffarpur, Saran, Vaishali, Buxar, Arwal, Aurangabad, Gaya, Nawada, Jamui



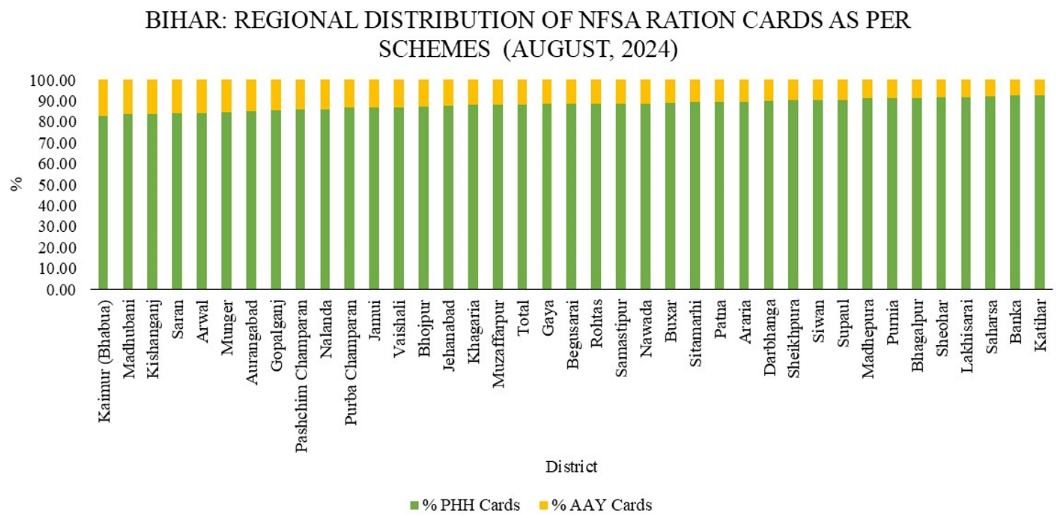
Source: *Compiled by Authors*

Figure 5: Rural-urban distribution of NFSA Ration cards

(d) Districts where more than 95% of the issued ration cards are in rural areas – 12 districts come under this group namely Sheohar, Sitamarhi, Madhubani, Supaul, Araria, Madhepura, Gopalganj, Siwan, Samastipu, Khagaria, Banka, Kaimur (Bhabhua)

The district with the highest percentage of ration cards in rural areas is Samastipur where by August 2024 98.09% of the total NFSA ration cards issued were rural.

Regional Distribution of NFSA Ration Cards according to Schemes: In Bihar as pointed earlier NFSA ration cards are issued under two schemes, viz. PHH and AAY. The PDS is dominated by the PHH cards. Out of the total cards issued in the state by August 2024, 88.3% have been issued under the PHH scheme and only 11.7% have been issued under the AAY scheme. The coverage of PHH scheme is more than that of AAY scheme. At the regional level also the same is found to be true. Based on the proportion of PHH cards to AAY cards the districts can be grouped under three broad categories, viz.



Source: *Author's own based on Calculations from Annavitran Abstract for the month of August 2024 (AePDS, Food and consumer Protection Department, Government of Bihar)*

Figure 6: Regional distribution of NFSA ration cards as per schemes in Bihar

(a) Districts having a High Proportion of PHH Cards (where 80%-85% of the ration cards are PHH cards) – Seven districts of the state, i.e. Kaimur (Bhabhua), Madhubani, Kishanganj, Saran, Arwal, Munger, and Aurangabad come under this group. Kaimur has recorded the lowest percentage of PHH cards to total cards (82.71%) amongst the districts.

(b) Districts having a Very High Proportion of PHH Cards (where 85%-90% of the ration cards are PHH cards) – Twenty districts of Bihar come under this category. They Are Gopalganj, Paschim Champaran, Nalanda, Purba Champaran, Jamui, Vaishali, Bhojpur, Jehanabad, Khagaria, Muzaffarpur, Gaya, Begusarai, Rohtas, Samastipur, Nawada, Buxar, Sitamarhi, Patna, Araria and Darbhanga.

(c) Districts Having an Extremely High Proportion of PHH Cards ((where 90%-95% of the ration cards are PHH cards) – Eleven districts come under this category. They are Sheikhpura, Siwan, Supaul, Madhepura, Purnea, Bhagalpur, Sheohar, Lakhisarai, Saharsa, Banka and Katihar. Katihar has the highest proportion of PHH cards (92.50%)

Distribution of PDF Beneficiaries: As per August 2024 there were 842.64 lakh beneficiary members of Public Distribution System in Bihar out of which 746.93 lakhs, i.e. 88.64% of the total beneficiaries were the beneficiary of PHH cards and 95.70 lakh persons, i.e. 11.36% of the total beneficiaries were the beneficiary of AAY cards.

Sale of Essential Commodities: From 2020 to 2024 only two commodities have been sold by the Public Distribution System in Bihar, i.e. Wheat and Rice. Whether it is the PHH sales or the AAY sales the quantity of rice sold is more than the quantity of wheat both in 2020 and in 2024. (Table 3 & Table 4)

Table 3 : Bihar - Sale of Essential Commodities under PDS (2020 & 2024)

Year	PHH Scheme (Sale in Kgs.)			AAY Scheme (Sale in Kgs)		
	Wheat	Rice	Fortified Rice	Wheat	Rice	Fortified Rice
2020	138634396	207947828.5	-	30398163	46432468	-
2024	66833797.33	33007604.8	234538457.3	14662092.96	6684103.18	51989642.79

Source: *Compiled from Annavitran sales Abstract of August 2020 and August 2024*

Table 4 : Bihar - Sale of Wheat vs Sale of Rice under PDS (2020 & 2024)

Year	2020	2024
Total Sale of Wheat (in kg)	169,032,559	81,495,890.29
Total Sale of Rice (in kg)	254,380,296.5	326,219,808.07

Source: *Compiled from Annavitran sales Abstract of August 2020 and August 2024*

Limitations and Future Work: This study suffers from the limitation that it could not do a comparative population analysis with the growth of priority households in absence of census data post 2011. Therefore, future works would look into an analysis of the growth of population and growth of PDS and PHH.

Findings & Conclusion

While Bihar ranked eighth in the state ranking index for NFSA in 2022 in the comprehensive country level index, our findings show that the coverage of Public Distribution System in Bihar has not shown improvement between 2011 and 2024. There has been a negligible growth in the Public Distribution System during the last five years (2020-2024) in Bihar, whether it is the Fair Price Shops or NFSA ration cards. The PDS is dominated by PHH card holders and PHH cards have more beneficiaries. There is district level variation in the number of ration cards. The coverage of Public Distribution System is more in rural areas as compared to the urban areas. The amount of rice far exceeds the amount of wheat sold through the Public Distribution System in Bihar both in case of AAY cards and PHH cards. No sale of coarse grain is made through the Public Distribution System. The PDS has now become online in Bihar but an insufficient digital education makes the needy unable to access the registration to this system. Proper identification of potential beneficiaries at grass root level is the need of the hour to increase the coverage of Public Distribution System. As up to now the PDS is only providing cereals to the existing beneficiaries. Diversification in the commodities made available through it can lead to balanced nutrition. There may be existing leakages to this system like hoarding and black-marketeering, that need to be identified, monitored and managed to increase the efficiency of the Public Distribution System, eventually leading to the achievement of food security in Bihar.

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BIHAR'S GREEN HORIZON: INTEGRATING AGROFORESTRY TO EXPAND FOREST COVER WITHIN THE STATE'S AGRICULTURAL ROADMAP

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ABSTRACT

Population pressure, climate change, and other environmental factors have significantly stressed the biodiversity of Bihar's natural forests. To address this, the government has adopted an ecosystem-based approach within the Agriculture Roadmap framework to conserve forests, water bodies, soil, and biodiversity, while increasing green cover. Bihar launched its first Agriculture Roadmap in 2008 with the aim of ushering in a "Rainbow Revolution" in agriculture and allied sectors. This was followed by the second Roadmap in 2012, the third in 2017, and now the fourth in 2023. These roadmaps have collectively supported Bihar in advancing its goals of food security, employment generation, and sustainable agricultural development, with environmental concerns integrated throughout. As a result, forest cover has risen from 6.65% to 14.75%. Large-scale sapling plantations have been conducted via the Agriculture Department, MNREGA, National Horticulture Mission, and NGOs. However, due to limited land availability, recurring floods, droughts, and other challenges, tree plantation efforts remain difficult in the state. This study identifies the Agriculture Roadmaps' objectives concerning green cover, agroforestry, and biodiversity; evaluates achievements under the Hariyali Mission in the first three Roadmaps; and reviews strategies in the fourth Roadmap. The analysis relies on secondary data from the Agriculture Department, Forest Survey of India, and credible online sources, supplemented by primary data from an online survey. The study provides clear, measurable objectives for expanding green cover, helping policymakers set aligned and integrated targets. Ultimately, it offers robust, evidence-based guidance for designing policies that link environmental sustainability with agricultural development in Bihar.

Keywords: Agriculture Roadmap, Agroforestry, Climate Change, Hariyali Mission, Rainbow Revolution.

Introduction

Bihar, an agrarian state in eastern India, faces significant environmental challenges, including deforestation, soil degradation, and erratic climate patterns, which impact agriculture, livelihoods, and ecological stability. To address these, the government launched the Bihar Agriculture Roadmap (BARM) in 2008, promoting an ecosystem-based approach for a

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Rainbow Revolution—an integrated agricultural improvement. The initiative has evolved through several phases: the First Roadmap (2008–2012), the Second Roadmap (2012–2017), the Third Roadmap (2017–2022), and the ongoing Fourth Roadmap (2023–2028). These plans have been instrumental in achieving key goals such as food security, employment generation, and sustainable agricultural development. Bihar's efforts have earned it five Krishi Karman Awards from the Government of India for excellence in agriculture (Fourth Agriculture Roadmap, Department of Agriculture, Government of Bihar, 2023).

Over the past 30 years, Bihar has faced accelerated environmental degradation, including green cover loss, extreme weather, and rapid urbanization. Rising temperatures, groundwater depletion, heat stress, pest infestations, and tree felling for urban projects have worsened the ecological imbalance. The urban heat island effect has become increasingly noticeable—actual temperatures of 41°C often feel like 44°C. These challenges have heightened public and government urgency for environmental restoration and expanding green cover. To address these challenges, Bihar has launched initiatives like the Jal-Jeevan-Hariyali Abhiyan, MGNREGA-linked plantations, and schemes under the Agriculture Roadmap.

Several studies have evaluated these efforts. For instance, Tripathi (2020) used satellite data to analyse the dynamics of land use and land cover across districts. Singh and Raizada (2021) and Singh et. al. (2021) identified two effective agroforestry models in Vaishali and Samastipur.

1. The Agri-Horticultural (AH) System, which offers higher economic returns and resilience to climate stress.
2. The Agri-Silvicultural (AS) System which improves soil organic carbon and delivers early returns due to shorter gestation periods.

Despite progress, major gaps remain. Most studies prioritize plantation numbers over long-term outcomes like survival rates, biodiversity, or climate resilience. Local-level research is limited, with little focus on agroclimatic diversity, species suitability, or urban green spaces. Socio-economic aspects—especially the roles of women and marginalized groups—are underexplored. Technology tools like remote sensing and AI are underused, and government data is often outdated or fragmented. A shift to inclusive, outcome-focused, tech-integrated approaches is crucial.

This study aims to address key research and implementation gaps by promoting evidence-based, district-specific planning that considers agroclimatic diversity and community input. Given Bihar's climate vulnerabilities, increasing green cover is both an environmental and developmental priority. It helps regulate microclimates, improve soil and water conservation, and sequester carbon. The study evaluates ecological and socio-economic impacts of afforestation, focusing on agroforestry, livelihoods, and community engagement to offer scalable, inclusive, and policy-relevant solutions for long-term sustainability and climate resilience.

Study Area

Bihar, a culturally and historically significant state in India, lies in the Middle Gangetic Plain and is divided by the River Ganga into northern and southern regions. Located between 24°20'10"–27°31'15" N latitude and 83°19'50"–88°17'40" E longitude, the region has an average elevation of 53 meters. As per the 2011 Census, Bihar has a population of 10.3 crore, with 88.7% in rural and 11.30% in urban areas, a density of 1,102 people per km^2, and a total area of about 94,163 km^2.

Image Source: *Government of Bihar. (n.d.). Administrative units [Bihar State Profile]. Retrieved June 18, 2025, from https://state.bihar.gov.in/main/Content.html?links&page=Bihar%20State%20Profile*

Figure 1 : District Map of Bihar

Objectives

- The primary objective of this paper is to identify and evaluate district-specific agroforestry practices within the state and to analyze the changes in green cover over time, particularly from 1995 to 2023.

- The second objective is to examine the objectives and achievements of all three Agriculture Roadmaps regarding the increase of the green cover in the state under the Hariyali Mission.
- The third objective is to assess the strategies and programmes outlined in the fourth Agriculture Roadmap, with a particular focus on public participation in agroforestry. Evaluating the involvement of communities and stakeholders will help in understanding how collaborative efforts can contribute to the success of agroforestry practices and the expansion of green cover.

This paper aim to analyse the effectiveness of government programmes such as the Jal Jeevan Hariyali Mission, MGNREGA-linked afforestation, and the Bihar Agriculture Roadmap in promoting green cover and climate resilience. It also highlights the need for greater community participation, joint forest management, and social forestry for long-term sustainability.

Research Questions

1. How can green cover be increased in Bihar, given that a majority of the land is under agriculture and allied sectors?
2. What are the key success and failure factors in the implementation of these afforestation efforts?
3. Which areas are most suitable for plantation, considering agroclimatic and land-use conditions?
4. What are the long-term ecological and socio-economic impacts of afforestation initiatives in Bihar?
5. How effective are current state-led initiatives in increasing green cover and enhancing climate resilience?
6. What socio-economic factors influence farmers' and communities' participation in agroforestry and afforestation schemes?

Methodology

After the Green Revolution and rapid population growth, deforestation in Bihar worsened, with forest cover dropping to 6.65% after Jharkhand's separation in 2000. To assess green cover increases via agroforestry within Bihar's Agriculture Roadmap, this study adopts a mixed-methods approach, integrating both quantitative and qualitative data, along with temporal (past trends and current scenario) and district-level spatial analyses for a balanced micro-level assessment. Secondary data were obtained from a range of sources, including government reports, research publications, policy documents, and official statistics.

I. Literature review of studies conducted by government agencies and researchers on green cover and agroforestry in Bihar.

II. Official data were sourced from the Forest Survey of India (FSI), Bihar Remote Sensing Application Centre (BIRSAC), Department of Agriculture, Directorate of Economics and Statistics, and Finance Department (Government of Bihar), Census of India, and the Ministry of Environment, Forest and Climate Change (MoEFCC). Information was gathered from various documents and repositories.

Primary data were collected from 170 households using random purposive sampling across various districts of Bihar, including Patna, Nalanda, Nawada, Bhagalpur, East Champaran, Gaya, Jamui, Jehanabad, Kaimur, Rohtas, and West Champaran, among others. Fieldwork took place from March to June 2025 through field surveys and online questionnaires using Google Forms. The study assessed respondents' knowledge of green cover, identified suitable plantation areas, and evaluated long-term ecological and socio-economic impacts of afforestation. The collected data were then analysed and interpreted using appropriate statistical methods to draw meaningful conclusions.

Land Use Pattern in Bihar

Bihar, a key agrarian state for India's food security, shows high agricultural intensity amidst urbanization and resource challenges. With declines in production in states like Punjab and Haryana, Bihar is poised for a second green revolution. From 2008–09 to 2020–21 (Table 1), Bihar's total land area remained around 9.4 million hectares, with forests stable at about 621.64 thousand hectares (6.64%). However, land not available for cultivation rose from 2.1 million hectares (22.46%) to 2.18 million hectares (23.30%) in 2020–21, reflecting increased non-agricultural use and shifting priorities.

The area of permanent pastures and grazing lands declined slightly, possibly due to urbanization or reduced livestock land. Miscellaneous tree crops and groves grew from 2.57% to 2.68%, reflecting agroforestry expansion. Culturable wasteland declined by 0.02%, aided by government initiatives like the Agriculture Roadmap, MGNREGA, and Jal Jeevan Hariyali Mission. Trees were planted along rivers, roads, highways, fields, and in public spaces. Current fallow lands increased from 655.17 thousand hectares (7.00%) to 1,002.96 thousand hectares (10.72%), likely due to water scarcity, profitability issues, or changing cropping patterns.

Table 1: Land Use Pattern in Bihar in 2008-09, 2011–12, and 2020-21

Land use	2008-09		2011–12		2020-21	
	Area in '000 ha	% of Total Geographical Area	Area in '000 ha	% of Total Geographical Area	Area in '000 ha	% of Total Geographical Area
Total geographical area	9416					
Reporting area for land utilisation	9359.57	100.00	9,359.57	100.0	9,359.57	100.0
Forests	621.64	6.64	621.64	6.6	621.63	6.64
Not available for cultivation	2102.22	22.46	1,702.54	18.2	2181.11	23.30
Permanent pasture and other grazing lands	15.87	0.17	15.70	0.2	14.91	0.16
Land under miscellaneous tree crops and groves	242.86	2.59	244.57	2.6	250.98	2.68
Culturable wasteland	45.43	0.49	45.23	0.5	43.58	0.47
Fallow lands other than current fallows	122.30	1.31	431.72	4.6	174.01	1.86
Current fallows	655.17	7.00	781.26	8.3	1002.96	10.72
Net area sown	5554.08	59.34	5,395.75	57.6	5070.39	54.17
Gross Cropped Area	7670.95	—	7,646.76	—	7246.00	—
Cropping Intensity	1.38	—	1.42	—	1.44	—

Data Source for 2008–09: *Ministry of Agriculture, Government of India. (2009). Land use statistics 2008–09.*

Data Source for 2011–12: *Finance Department, Government of Bihar. (2012). Economic survey 2011–12.*

Data Source for 2020–21: *Ministry of Environment, Forest and Climate Change, Government of India. (2023). India State of Forest Report 2023.*

Bihar's net sown area declined from 5,554.08 thousand hectares (59.34%) to 5,070.39 thousand hectares (54.17%), and the gross cropped area dropped from 7,670.95 to 7,246.00 thousand hectares, showing reduced agricultural activity. However, cropping intensity rose from 1.38 to 1.44, indicating more intensive land use through multiple cropping. These trends reflect growing urbanization and changing farming practices, with major relevance to food security and land use planning.

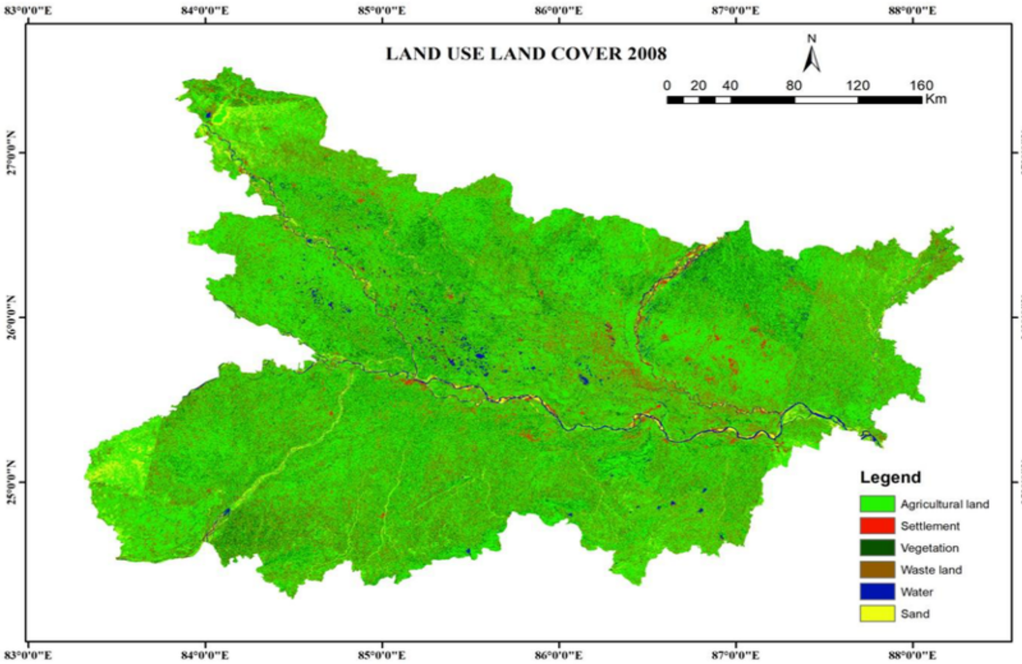


Image Source: *Bhawana and Sudarshan Prasad (June 2019)*

Figure 2: Land Use and Land Cover (LULC) Map of Bihar, 2008

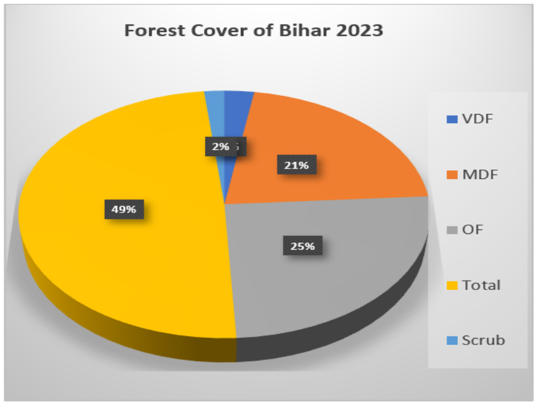
Quantitative Analysis of Forest Cover in Bihar

Population pressure, climate change, and environmental stress have impacted Bihar's forest biodiversity. At COP-28 (2023), Bihar highlighted its afforestation efforts under the Jal-Jeevan-Hariyali Mission. Since 2012–13, over 348 million saplings have been planted (Table 6) by the Agriculture Department of Bihar, MNREGA of the Rural Development Department, the Horticulture Mission, and NGOs. Forest cover rose from 7.27% in 2008 to 14.75% in 2019 (Amit Bhelari, 2023). Despite challenges like limited land, floods, and droughts, the state has introduced a green budget and promotes climate-resilient agriculture and agroforestry to address climate change and biodiversity loss.

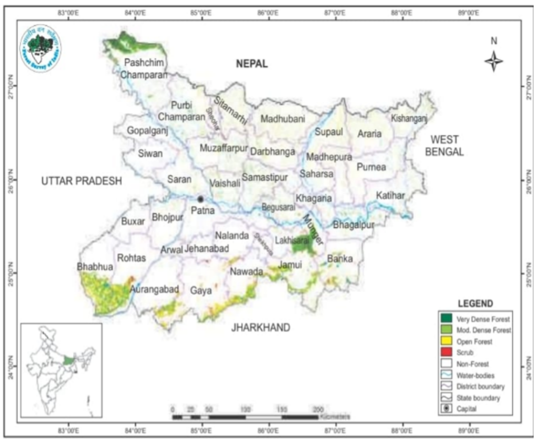
According to Table 2, Bihar's forest and scrub area is 7,532.45 km², which accounts for 8% of the state's total area. Moderately Dense Forest (MDF) is the largest category at 3,284.21 km² (3.49%), while scrub covers 260.80 km² (0.28%) (India State of Forest Report 2023, MoEFCC). The data indicates modest forest cover, with scrub areas pointing to degradation, highlighting the need for restoration efforts to support biodiversity and environmental health.

Table 2 & Fig. 3: Forest cover of Bihar, 2023 (km²)

Class	Area	% of Calculated Area by SoI
Very Dense Forest (VDF)	387.00	0.41
Mod. Dense Forest (MDF)	3,284.21	3.49
Open Forest (OF)	3,861.24	4.10
Total	7,532.45	8.00
Scrub	260.80	0.28



Data Source: *Forest Survey of India. (2023). India State of Forest Report 2023. Ministry of Environment, Forest and Climate Change, Government of India.*



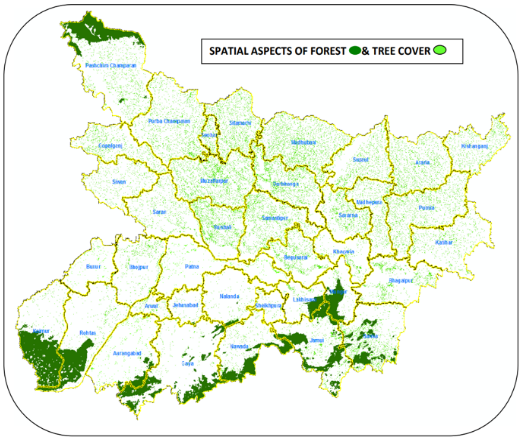
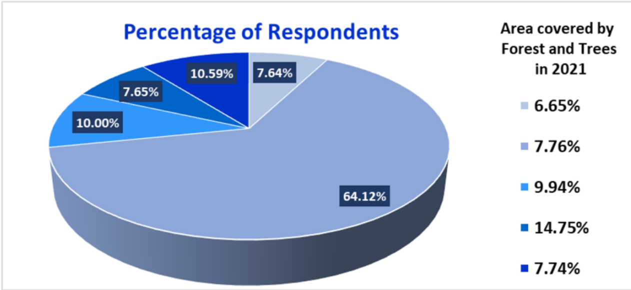


Image Source: *Fig. 4 A: Forest Survey of India, Bihar*
Fig. 4 B: Bihar Remote Sensing Application Centre, Department of Science and Technology, Government of Bihar

Figure 4 A & B: Forest Cover Map of Bihar

Data in Figure 5 reflects varied public perceptions of Bihar's forest cover in 2021. 64.12% of respondents estimated it at 7.76% and 10.59% at 14.75%. This suggests a gap between public perception and actual figures. This underscores the need for ongoing environmental education to align public understanding with reality.



Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 5: Area covered by Forest and Trees in 2021 (in Percentage) according to Respondents

Forest Cover Analysis: Bihar vs. Jharkhand

After separating from Jharkhand, Bihar's forest cover dropped sharply by 81.8% between 1995 and 1999, while Jharkhand's declined by 18.5%. Since 2001, both states have shown forest recovery, with Bihar's cover growing by 18.43% and Jharkhand's by 4.59% (Table 3). Over the past decade, growth has slowed—Bihar rose 2.05% and Jharkhand 0.19% from 2021 to 2023. Overall, Bihar has shown a stronger and more consistent forest recovery than Jharkhand.

Table 3: Assessment of Forest Cover: Bihar vs. Jharkhand (1995- 2023) (Area in sq. km.)

Year	Bihar Assessment	% Change (Bihar)	Jharkhand Assessment	% Change (Jharkhand)
1995	26,561	-	-	-
1999	4,830	-81.8	21,644	-18.5
2001	5,720	+18.43	22,637	+4.59
2005	5,579	-2.47	22,591	-0.20
2009	6,804	+21.96	22,894	+1.34
2011	6,845	+0.60	22,977	+0.36
2013	7,291	+6.51	23,473	+2.16
2015	7,288	-0.04	23,478	+0.02
2017	7,299	+0.15	23,553	+0.32
2019	7,306	+0.096	23,611	+0.25
2021	7,381	+1.03	23,721	+0.47
2023	7,532.45	+2.05	23,765.78	+0.19

Data Source: *Compiled from the Forest Survey of India. (2001–2023). State of Forest Reports (2001, 2005, 2009, 2011, 2013, 2015, 2017, 2019, 2021, 2023). Ministry of Environment, Forest and Climate Change, Government of India.* https://www.fsi.nic.in

A. District-wise change in Green Cover from 2021 to 2023

In 2023, Bihar's forest area was 7,532.45 km², accounting for 8% of the state, with a net gain of 129.19 km² since 2021, as per Forest Survey of India data (Table 4). Top districts for forest growth include Bhagalpur (+33.82 km²), Madhubani (+25.71 km²), East Champaran (+19.44 km²), Banka (+19.16 km²), Gaya (+10.76 km²), and Sitamarhi (+12.99 km²). Major losses occurred in Kaimur (−35.35 km²), Nawada (−9.76 km²), Kishanganj (−7.56 km²), Begusarai (−5.31 km²), and Samastipur (−4.00 km²).

Table 4: District-wise Forest Cover in Bihar (ISFR 2023)

District	Forest Area (km²)	% of Calculated Area by SoI	Change w.r.t. 2021 Raster based*
Araria	146.64	5.10	-1.64
Arwal	4.02	0.63	0.00
Aurangabad	157.78	4.77	3.97
Banka	295.52	9.79	19.16
Begusarai	79.50	4.14	-5.31
Bhagalpur	103.31	4.02	33.82
Bhojpur	31.57	1.32	-0.98
Buxar	6.01	0.35	-0.11
Darbhanga	144.23	6.33	6.69
East Champaran	187.42	4.72	19.44
Gaya	622.49	12.51	10.76
Gopalganj	11.30	0.56	2.64
Jamui	670.84	21.65	5.24
Jehanabad	6.10	0.66	1.30
Kaimur	1025.68	30.51	-35.35
Katihar	65.39	2.14	3.63
Khagaria	17.62	1.19	-0.50
Kishanganj	95.27	5.06	-7.56
Lakhisarai	169.54	13.81	1.38
Madhepura	60.01	3.36	6.17
Madhubani	232.18	6.63	25.71
Munger	306.01	21.57	3.30
Muzaffarpur	175.76	5.54	6.31
Nalanda	44.81	1.90	5.41

Nawada	506.30	20.30	-9.76
Patna	28.37	0.89	0.00
Purnia	60.68	1.88	5.09
Rohtas	668.06	17.35	1.66
Saharsa	35.83	2.12	2.86
Samastipur	149.24	5.14	-4.00
Saran	62.79	2.38	3.40
Sheikhpura	0.82	0.12	0.00
Sheohar	30.43	8.72	3.84
Sitamarhi	151.90	6.62	12.99
Siwan	9.41	0.42	2.00
Supaul	142.46	5.87	6.19
Vaishali	118.93	5.84	0.05
West Champaran	908.23	17.37	1.39
Grand Total	7532.45	8.00	129.19

**Area figure calculated without normalization factor.*
***Data Source:** Forest Survey of India. (2023). India State of Forest Report 2023: Volume II. Ministry of Environment, Forest and Climate Change, Government of India.*
https://fsi.nic.in/uploads/isfr2023/isfr_book_eng-vol-2_2023.pdf

Kaimur (30.51%), Jamui (21.65%), Munger (21.57%), Nawada (20.30%), and Rohtas (17.35%) possess the largest forest cover in Bihar, forming its core tree cover zones. However, Kaimur and Nawada have recently seen declines. In contrast, districts like Sheikhpura, Buxar, Arwal, and Siwan have under 1% forest cover. While overall forest cover is gradually improving, forest-rich areas like Kaimur and Nawada need focused conservation efforts.

The last census of Bihar was conducted in 2011, and the next census, scheduled for 2021, has been postponed until 2025. But the Census of India has a population projection for Bihar 2025. On the basis of these data correlation between green cover and projected population has been calculated and analysed.

Table 5: Projected Population and Forest Cover of Bihar (2001-2023)

Year	Projected Population in crores (x)	Forest Cover in hectares (y)	x^2	y^2	xy
2001	8.30	5720	68.89	32718400	47476.00
2011	10.41	6845	108.37	46854025	71256.45
2021	12.67	7381	160.53	54479161	93517.27
Total	31.38	19946	337.79	134051586	212249.72

***Data Source:** Bihar Population 2025 | Sex Ratio | Literacy. Population Census*
https://www.census2011.co.in/census/state/bihar.html

Karl Pearson's coefficient of correlation between the projected population and forest cover over the years:

To determine Pearson's correlation coefficient (r), the following formula is applied:

$$r = n\sum xy-(\sum x)\,(\sum y) \,/\, \sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}$$

Where n denotes the number of data points, x represents the projected population, and y represents the forest cover.

$$r = 3\times212249.72 - (31.38\times19946)/\sqrt{[3 \times 337.79 - (31.38)^2]\,[3 \times 134051586 - (19946)^2]}$$

$$= 636749.16 - 625905.48/\sqrt{[1013.37 - 984.70][402154758 - 397842916]} = 10843.68/11118.476$$

Pearson's correlation coefficient (r) was calculated as 0.975.

The value of r = 0.975 indicates a very strong positive link between Bihar's population growth and forest cover increase, suggesting they rise together. However, this is based on just three data points (2001, 2011, 2021), limiting reliability. The correlation doesn't imply causation, as factors like policy, land use, and conservation efforts also influence forest cover. More data and broader analysis are needed for clearer insights.

Qualitative Analysis - Policy review of Bihar Agriculture Roadmap and Green Missions

The Bihar Agriculture Roadmap (launched in three phases: 2008–2012, 2012–2017, 2017–2022 and 2023-2028) is a multi-phase initiative integrating 12 departments to align efforts in agriculture, environment, and forestry. It promotes Integrated Farming Systems (IFS) and agroforestry practices like alley cropping and windbreaks. Agricultural universities collaborate to develop region-specific models that boost soil fertility, water conservation, and farm productivity.

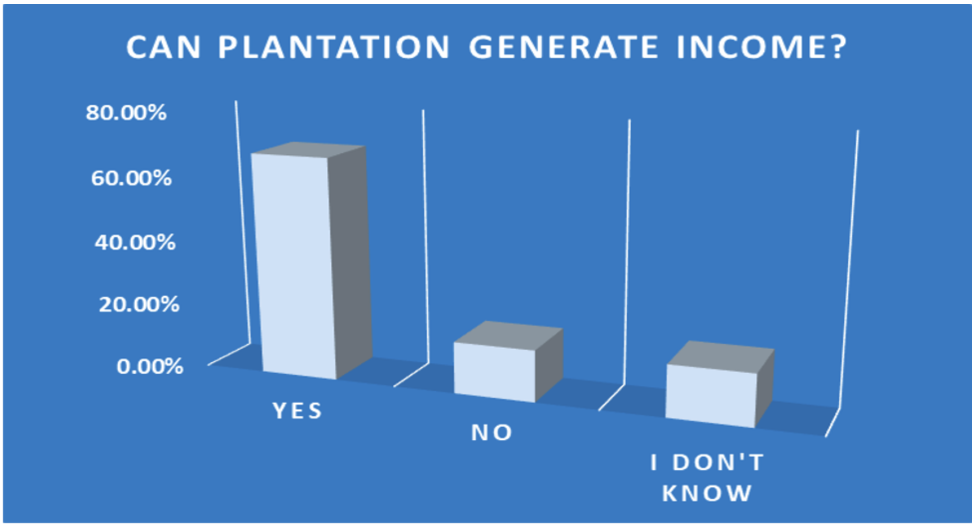
First Agricultural Roadmap (2008-2012)

Launched in 2008, Bihar's First Agricultural Roadmap aimed to drive a rainbow revolution in agriculture and associated sectors. In 2011–12, the state received the Krishi Karman Award for excellence in rice production. In 2012–13, total foodgrain output reached 178.29 lakh tonnes (Agriculture Department, Govt. of Bihar). The Environment, Forest and Climate Change Department has supported this progress through large-scale plantation drives to mitigate floods, droughts, and climate change.

Second Agricultural Roadmap (2012- 2017)

Launched in October 2012 by President Pranab Mukherjee, Bihar's Second Agricultural Roadmap aimed to boost food and nutritional security, increase farmer incomes, generate employment, reduce migration, and promote inclusive agricultural development with active participation of women. It also focused on improving road connectivity, ensuring adequate electricity supply, enhancing storage facilities, encouraging food processing initiatives, and conserving and optimizing the use of natural resources. Key programs included the Seed Extension Scheme, bio-farming, modern equipment, SRI technique, and agricultural extension services. The Green Mission targeted a forest cover rise from 9% to 15% by 2017, with a goal of planting 23.95 crore trees—18.47 crore were actually planted. One agricultural university and three colleges were set up in Saharsa, Purnia, and Kishanganj. Farmers were also sent to China for training. Bihar won the Krishi Karman Awards for wheat in 2012–13 and maize in both 2015–16 and 2016–17 (Department of Agriculture, Government of Bihar, 2023).

A majority (68.24%) of respondents believe plantations can generate income, supporting community-driven afforestation efforts. However, 15.88% disagree and another 15.88% are unsure, indicating an awareness gap that could be addressed through targeted campaigns or demonstration projects.



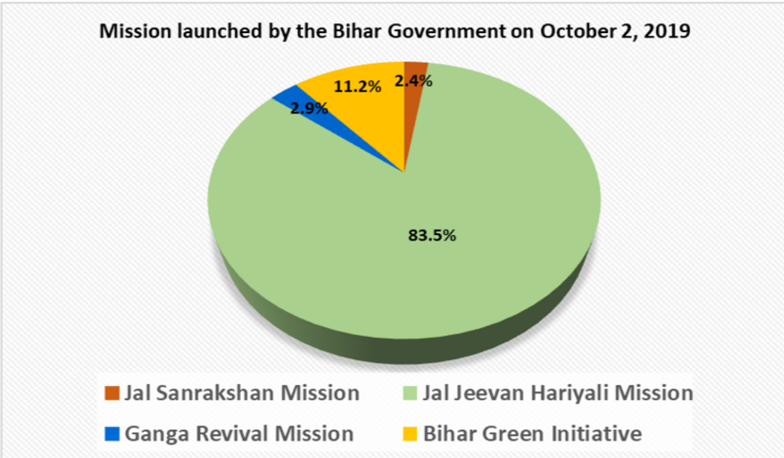
Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*
Image Source: *Photograph taken by the author (2024–2025).*

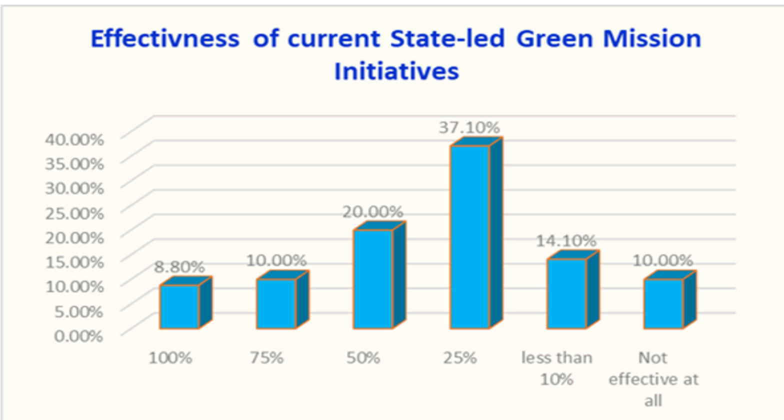
Figure 6: Can Plantation Generate Income?

Third Agricultural Roadmap (2017 – 2022)

The Third Agricultural Roadmap, launched by President Ram Nath Kovind on November 9, 2017, aimed to put "a dish of Bihar on every Indian's plate" over five years. It focused on boosting agricultural quality, strengthening export infrastructure, and creating an organic corridor along the Ganga. It introduced nutritious food in the Mid-Day Meal Scheme and earned Bihar the Krishi Karman Award for wheat production in 2017-18. The Jal Jeevan Hariyali Mission targeted 15% forest cover by planting 16.33 crore trees and adding 2.5% greenery. Key goals included promoting agroforestry, conserving wetlands, soil and water conservation, developing 120 urban parks, creating markets for tree-based products, and supporting climate resilience.

Data in Figure 7 shows that 83.5% of respondents recognized the Jal Jeevan Hariyali Mission (launched Oct 2, 2019), while awareness of other initiatives is low: Jal Sanrakshan Mission (1.9%), Ganga Revival Mission (3.1%), and Bihar Green Initiative (11.2%). Public confidence in state-led green cover initiatives is limited, with only 8.8% rating them as fully effective, and 37.1% at 25% effectiveness. Nearly a quarter view them as minimally or not effective at all. This suggests a need for more impactful, visible, and community-driven afforestation efforts.





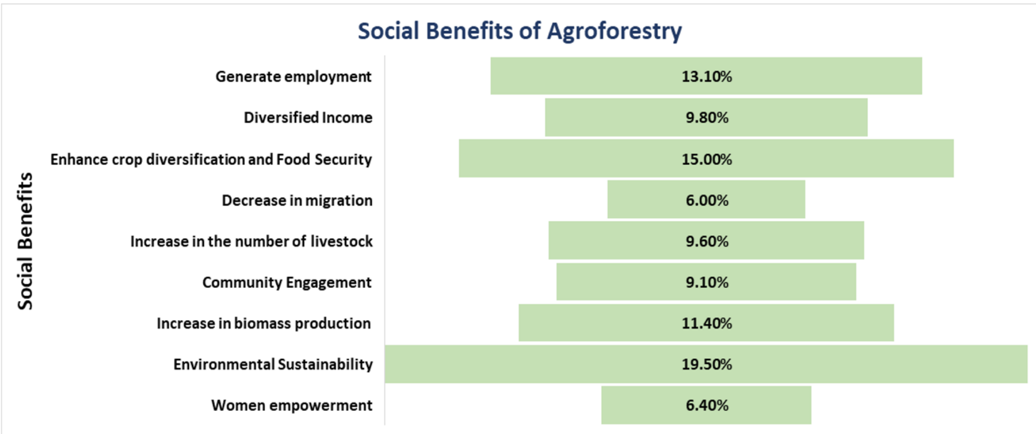
Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 7: Awareness among respondents about Jal Jeevan Hariyali Mission

The impact of these three agriculture roadmaps on green cover can be assessed under the following initiatives:

i. Promotion of Agroforestry and Horticulture

The Bihar government promotes sustainable agriculture by integrating fruit, medicinal, and timber trees into traditional cropping systems, offering financial and technical support for orchard development, especially in districts with low-forest areas. The Department of Horticulture encourages Mango, Litchi, and Guava plantations with up to 50% subsidy and pest management aid. The data (Fig. 8) highlights agroforestry benefits recognized by respondents: environmental sustainability (19.5%), food security and crop diversification (15%), and employment generation (13.1%). Other noted benefits include biomass production (11.4%), diversified income (9.8%), and community engagement (9.1%). Lower awareness of women empowerment (6.4%) and reduced migration (6%) suggests a need for more focus on these areas.

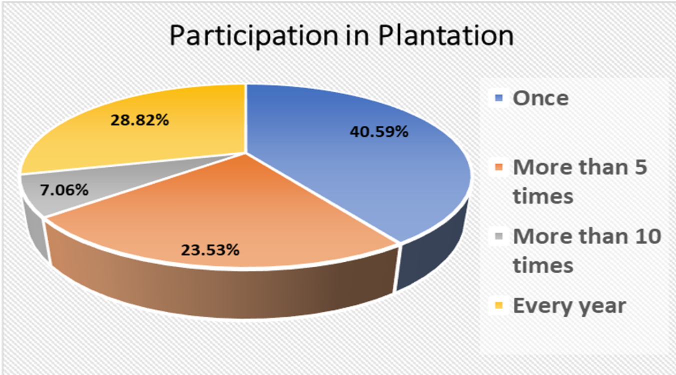


Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 8: Social Benefits of Agroforestry

ii. Social Forestry and Community Participation

The Bihar government has launched widespread tree plantation drives on government, community, and private lands, including roads, canals, and railways, to boost green cover. Van Mahotsav in July encourages community involvement, led by Panchayati Raj Institutions, schools, NGOs, and Village Forest Committees. The data (Fig. 9) shows 40.59% of people participated once, 28.82% annually, 23.53% over five times, and 7.06% more than ten times. While engagement is positive, many one-time participants suggest a need to encourage long-term involvement.



Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 9: Participation of Respondents in Plantation Programmes

iii. Watershed Development and Soil Conservation

The Bihar government is boosting green cover and combating soil erosion through afforestation and bio-engineering in vulnerable regions. Grasses are planted to reduce runoff, bind soil, and stabilize degraded lands and embankments, improving ecological resilience.

iv. Integration under the MGNREGA Scheme

Under BARM, Bihar aligned with MGNREGA to promote afforestation and land development, linking job creation with environmental conservation. While 63.53% of respondents recognized its livelihood goal, only 8.82% noted its environmental impact, and just 2.35% were aware of the one-third job reservation for women, indicating the need for better outreach on its broader benefits (Fig. 10).

Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*
Image Source: *Photograph taken by the author (2024–2025).*

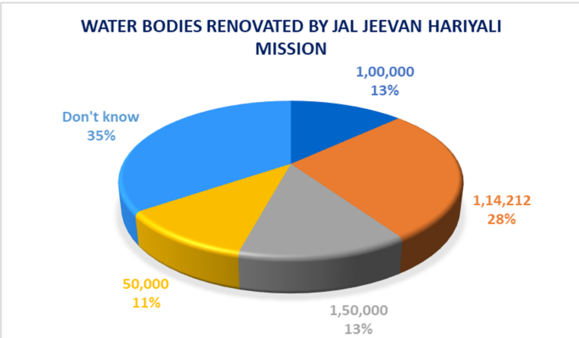
Figure 10: Key Aspects of MGNREGA according to Respondents

v. Promotion of Sustainable Agriculture

The Bihar government is promoting sustainable agriculture by encouraging organic and natural farming to reduce chemical use. Key initiatives include green manuring and multi-cropping systems that integrate tree and shrub species.

vi. The Jal-Jeevan-Hariyali Mission (JJHM)

Launched on October 2, 2019, the Jal-Jeevan-Hariyali Mission (JJHM) is Bihar's key initiative to combat climate change and promote sustainability, based on the motto "Water, Life, and Greenery – Only Then Will There Be Prosperity (जल-जीवन-हरियाली, तभी होगी खुशहाली)." As of 2023, the state has 870 nurseries and has planted 12.18 crore saplings under dense plantations. Additionally, 36,999.86 acres are under organic farming, and 18,766.55 acres are irrigated using drip and sprinkler systems (Govt. of Bihar, 2022–23). The data reflects that although 27.65% of respondents accurately identified the 1,14,212 renovated water bodies, 34.71% were unaware, highlighting the need for greater public awareness of the mission's progress.



Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*
Image Source: *Photograph taken by the author (2024–2025).*

Figure 11: Water bodies renovated by the Jal Jeevan Hariyali Mission according to Respondents

Fourth Agricultural Roadmap (2023 – 2028)

Launched on October 18, 2023, by President Droupadi Murmu, Bihar's Fourth Agriculture Road Map is a Rs. 1.62 lakh crore plan to boost productivity, crop diversification, and sustainability. Building on past successes in paddy, wheat, maize, and leadership in mushroom, honey, makhana, and fish production it aims to tackle challenges like limited forest land. The state has planted 18.47 crore trees (2012-17) and 16.32 crore (2017–2023) with a target of 20 crore by 2028 to increase green cover from 14.75% to 17% (Agriculture Road Map, Govt. of Bihar). The plan also supports marginal and women farmers and encourages investments for inclusive growth.

Table 6: Achievement in Plantation in Past Agriculture Roadmaps

Krishi Road Map	Target	Achievement (in lakh)
IInd ARM (2012-17)	2395.00	1847.16
IIIrd ARM (2017-23)	1810.00	1632.93
Total Plantation	4205.00	3480.09

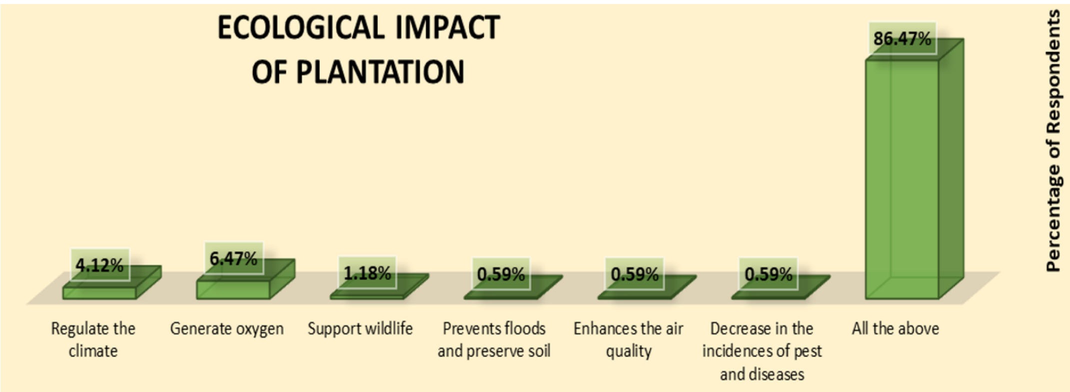
Data Source: *Department of Agriculture, Government of Bihar. (2023). Fourth Agriculture Road Map 2023–28 (p. 296).* https://state.bihar.gov.in/cache/29/Media%20Gallery/Publications/1a.pdf

The Strategies and Programmes of the Fourth Agriculture Roadmap

The Fourth Agriculture Roadmap outlines strategies to enhance forest cover, conserve water in forest areas, and promote tree plantation on both government and private lands. It emphasizes developing nurseries, producing tissue culture-based teak and bamboo plants, and establishing bamboo research centres. Key focus areas include wetland conservation, development of region-specific agricultural zones (Tal, Diara, Chaur), promoting forest-based industries, and ensuring coordination between government departments and the private sector.

Ecological Impact of Plantation (According to Respondents)

The majority of respondents (86.47%) believe that tree plantation has a comprehensive ecological impact, contributing to climate regulation, oxygen generation, wildlife support, flood prevention, soil conservation, improved air quality, and reduced pest and disease incidences. A smaller percentage highlighted individual benefits such as oxygen generation (6.47%) and climate regulation (4.12%), indicating strong overall awareness of the multifaceted environmental benefits of tree plantation.

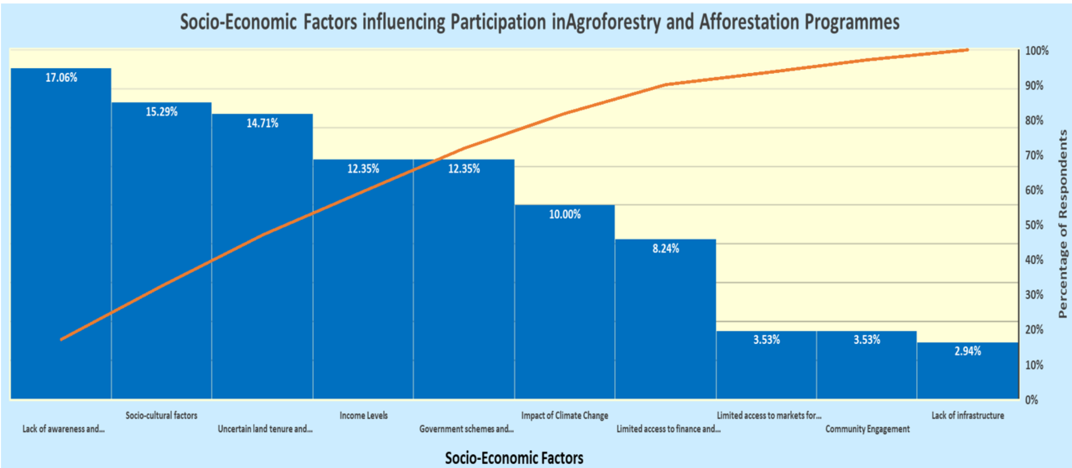


Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 12: Ecological Impact of Plantation

Socio-Economic Factors influencing Farmers' and Communities' Participation (According to Respondents)

Data reveals that lack of awareness and technical knowledge (17.06%) is the most significant socio-economic barrier to participation in agroforestry and afforestation programs in Bihar. Other major factors include socio-cultural influences (15%), uncertain land tenure (14.71%), income levels and access to government schemes (both 12.35%), and the impact of climate change (10%). Limited access to finance, markets, and infrastructure, along with weak community engagement, also affect participation, highlighting the need for integrated support, awareness-building, and policy interventions to enhance involvement in these green initiatives.



Data Source: *Online survey conducted by the author using Google Forms (2025), N = 170.*

Figure 13: Socio-Economic Factors influencing Farmers' and Communities' Participation

What are the Success and Failure Factors in incorporating these Schemes?

According to respondents, increasing Bihar's green cover requires a multifaceted and coordinated approach with active community participation, scientific planning and sustainable land-use practices. Key factors include strong government support, clear policies, adequate funding, and integration with schemes like MGNREGA. Technical guidance, access to quality planting material, and monitoring ensure higher sapling survival. Technologies such as GIS, remote sensing, and geo-tagging improve planning, transparency, and accountability. Promoting agroforestry, securing land tenure rights, and building market linkages for forest produce also contribute to long-term sustainability. These combined ecological, institutional, social, and economic strategies are vital for successful afforestation in Bihar.

However, several factors undermine progress in Bihar's afforestation efforts. These include lack of community involvement, poor planning (unsuitable species and sites), inadequate funding, corruption and institutional weaknesses like skilled staff shortages and poor coordination. External challenges like climate change, droughts, floods, and pests also contribute to sapling mortality. Land tenure disputes and pressures from deforestation, overgrazing, infrastructure, and pollution further hinder success of green initiatives. Addressing these issues requires integrated planning, community engagement, better governance, proper species selection, and sustained post-plantation care.

Suggestions to Enhance Green Cover in Bihar According to Respondents

Here's a summarized version of the strategies to enhance Bihar's green cover, organized by key themes based on respondents' insights:

1. ***Tree Plantation and Afforestation Initiatives -*** Plantation drives should be strengthened with proper maintenance and expanded through schemes like Agroforestry-Poplar, Mission 5 Crore Tree, Harit JEEViKA, and Harit Bihar 5.0. A "Mission 1 Crore Tree Plantation" with GPS tracking can ensure transparency, while Miyawaki forests in cities like Patna, Muzaffarpur, and Gaya can enhance urban green cover.

2. ***Community and Citizen Engagement -*** Community participation can be enhanced by leveraging JEEViKA, forming Village Forest Committees (VFCs) under Joint Forest Management, and running campaigns such as "Every Sunday Eco-friendly Work" to encourage voluntary involvement. Additionally, establishing eco-clubs in schools and colleges can foster environmental awareness among the youth.

3. ***Institutional Support and Governance -*** Green initiatives can be strengthened by upgrading nurseries, enforcing tree-cutting bans, and fast-tracking afforestation clearances. A "Green Bihar Mission" with district-level targets and coordination through schemes like MGNREGA, RKVY, CAMPA, and NABARD should be launched, while farmers are supported with market linkages and drip irrigation.

4. ***Urban and Regional Green Planning -*** Urban planning should integrate green belts and trees as mandatory infrastructure, while promoting urban forestry and green corridors through Public-Private Partnerships (PPP).

5. ***Agroforestry and Land Use Transformation -*** Agroforestry and multi-layer cropping should be encouraged by providing farmers with subsidies, training, and market linkages, while promoting fruit orchards, medicinal trees, and tree integration on farm boundaries and public lands.

6. ***Conservation and Environmental Protection -*** Degraded lands should be reforested with native species, wetlands conserved, and soil and water restored using bio-engineering methods like vetiver grass and check dams, promoting biodiversity, sustainability, and reducing deforestation.

7. ***Technology and Monitoring -*** GIS and satellite mapping should be used to identify low green cover areas and monitor progress, complemented by mobile apps for plantation tracking and community reporting.

8. ***Awareness and Capacity Building -*** Workshops, rallies, media campaigns, and Van Mahotsav festivals should be organized to provide training on plant selection, agroforestry models, and innovative techniques, while fostering volunteerism and environmental responsibility.

9. ***Policy and Incentives -*** Incentives should be provided to farmers and institutions for tree planting, while promoting tree-based alternatives to firewood. Additionally, CSR investments from private companies should be encouraged to support afforestation projects.

These strategies aim to increase Bihar's green cover from 15% to 17% by 2028, promoting biodiversity, ecotourism, and mega plantations through collective action by communities, government, and private stakeholders.

Suitable areas and tree species for plantation in Rural Bihar (as per Respondents)

Based on community feedback and rural context, suitable areas for plantation and agroforestry include unused or barren lands, wastelands, field boundaries, community lands, agroforestry systems, roadsides, rail tracks, canals, rivers, pond embankments, public spaces, treated grazing and uncultivable lands, and homestead areas.

The region's diverse agro-climatic zones enable the cultivation of fruit trees like mango, guava, banana, lychee, papaya, pomegranate, apple, mulberry, and citrus fruits and timber trees such as teak, mahogany, sheesham, bamboo, and pongamia. The government promotes medicinal plants (like neem, tulsi, aloe vera, ashwagandha, and giloy) and spices to diversify agriculture and boost farmer incomes.

Suitable areas and tree species for plantation in Urban Bihar (as per Respondents)

Respondents recommended integrating green infrastructure in urban planning, following Chandigarh's model, to enhance green cover and ecological balance. Key areas for plantation include roads, parks, educational and institutional grounds, landscaped public spaces, green footpaths, rooftop and vertical gardens, residential communities, underused urban areas, buffers under flyovers and highways, waterfronts, and green transport corridors.

Urban plantations can include ornamental plants for beauty, shade trees to reduce heat, dwarf fruit trees for fresh produce, herbs for culinary and health benefits, and native species to support local ecology. Pollution-resistant trees like London Plane, Silver Birch, and Sycamore help remove harmful pollutants like $PM_{2.5}$, enhancing urban living quality.

Limitations to Landscape Greening Initiatives

Bihar's landscape greening faces challenges such as low forest cover, land tenure conflicts, climate vulnerability, weak monitoring, forest diversion, urban expansion, high sapling mortality, limited agroforestry adoption, and pressures from tourism, soil erosion, and pests. These challenges call for strategic land management, climate-resilient planning, improved monitoring, stronger conservation policies, and focus on community participation, private support, sustainable resource management, and economic enablement.

Conclusion

Bihar's agroforestry and afforestation initiatives have significantly enhanced green cover and advanced sustainable land use, largely driven by the Agriculture Roadmap's integration of agricultural development with environmental goals. Schemes such as the Jal Jeevan Hariyali Mission (JJHM), MGNREGA-linked community forestry, and dense plantation efforts have transformed sustainable agriculture. Key interventions include the promotion of agroforestry and horticulture, expansion of social forestry, and widespread community participation via Panchayati Raj Institutions, schools, NGOs, and Village Forest Committees, raising public awareness and support for afforestation. Notably, the fourth Agriculture Roadmap's focus on nursery development and the establishment of bamboo research and training centers has further boosted forest cover.

Despite these gains, significant challenges persist. Limited community engagement and awareness reduce sapling survival due to inadequate post-plantation care. Poor species selection, insufficient funding, bureaucratic hurdles, lack of trained personnel, and weak coordination further undermine initiatives, while climate change, floods, droughts, and pests pose ongoing risks. To overcome these issues and raise Bihar's forest cover to the national average, a multipronged, localized strategy is vital—one that prioritizes afforestation, agroforestry, and sustainable land-use practices based on ecological planning, strong institutional backing, and active community involvement. Policy planners can utilize the study's findings to design cross-sector policies that embed agroforestry within agriculture, rural development, and climate adaptation frameworks, leveraging survey data for participatory, field-relevant approaches that include all stakeholders.

Acknowledgement

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

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AN ASSESSMENT OF THE TOURIST FACILITIES AND CHANGING SCENARIOS IN THE BUDDHIST CIRCUIT IN BIHAR

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ABSTRACT

The Buddhist Circuit in Bihar is an important destination and pilgrimage center in the world. The study area, surrounding temples, monasteries, hotels, restaurants, and built-up areas, is experiencing rapid transformation with the ongoing visits of tourists. A decade ago, there was no well-developed infrastructure, network, and connectivity, a lack of basic utilities and hygiene, as well as problems of personal safety and security, including in hotels and restaurants. This not only created a negative image of the state but also had an adverse impact and demotivated tourists regarding the pilgrimage site in the study area.

Buddhist Circuit in Bihar is a region that holds deep religious and historical significance for the global Buddhist community. The present study investigates the movement, affiliation, and interest of international pilgrims, tourists, scholars, as well as domestic and religious tourists, contributing to the socio-cultural dynamics in areas such as Bodh Gaya, Nalanda, Rajgir, and Vaishali. This paper examines the changing scenarios and perceptions of tourists regarding the basic utilities, infrastructure, and facilities that tourists encounter.

Keywords: *Tourists, Facilities, Buddhist Circuit, Infrastructure, Pilgrimage.*

Introduction

Bihar is the sacred land of several Buddhist sites, which is not only a testament to its rich cultural heritage but also a significant destination for tourist attractions. These important sites are linked together to form a series of Buddhist circuits. The Buddhist Circuit is a path that follows the footsteps of Buddha, from Nepal, where he was born, through Vaishali, Nalanda,

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Rajgir, and Bodh Gaya (Bihar), where he attained enlightenment and a deep sense of spiritual consciousness, to Sarnath and Kushinagar (Uttar Pradesh), where he delivered his first sermon and attained Nirvana. The iconic route in Bihar includes the actual places where Buddha stayed and spent valuable time, awakening his mind, developing spiritual consciousness, and finally attaining enlightenment. The geographical and scenic beauty, along with a deep sense of affection and recognition of the sacred land, attracted Buddha to these sites, where he stayed for a long time during his journey. This area has remained a center of attraction from ancient to modern times due to its natural beauty and environment (Strong, 2008). However, the situation drastically changed and became alarming due to poor infrastructure, deteriorating roads and networks, lack of basic utilities and facilities, concerns over safety and security, as well as unfortunate incidents involving tourists. These issues have had an adverse impact on tourism in the Buddhist Circuit in Bihar. Presently, the central and state governments, foreign investors, temple management authorities, community organizations, NGOs, and local stakeholders have taken several initiatives to restore its glorious past. In this context, the study highlights the development of Buddhist monasteries, temples, and guest houses, as well as the role of tourism and pilgrimage in providing livelihoods. These developments have helped establish the region as a global destination and emerging market (Geary, 2009). In a similar study, it was found that the tourism industry has flourished, with many hotels and restaurants emerging to cater to the needs of tourists. This has led to the growth of various activities in the area, with local people engaged in providing services for both tourists and pilgrims, contributing to the socio-economic development of the community (Singh, 2013: 52). Ongoing programmers and schemes such as the city development plan, periodic draft master plan, and heritage development plan have resulted in progress, including improved infrastructure, road networks, connectivity, and essential facilities to attract tourists from across the globe. This study highlights how favorable and effective tourism policies have boosted both domestic and international Buddhist pilgrimage to Bihar, improving tourist perceptions (Upadhya, 2000). These developments have had significant and positive impacts on tourism in the study areas. The research also examines the changing scenarios and tourist perceptions in the region.

Objectives

1. To study the changing scenarios in the Buddhist Circuit in Bihar.
2. To access and examine the tourist facilities in the study area.

3. To examine the perception of tourists about their basic utilities and facilities available in the study area.

4. To study the issues and challenges of tourism in the study area.

Database and Methodology

This research paper is primarily based on primary data, supplemented by secondary data compiled from the Census of India 2011, previous literature and records, District Gazetteers, District Statistical Offices, Block Development Offices, government reports, and NGO publications. Primary data were collected through a structured questionnaire to fulfill the objectives of the research. The questionnaire covered key socio-economic indicators such as income levels, employment status, land ownership, education, access to public services, involvement in tourism, and perceived impacts of tourism development. A total of 800 samples (400 tourist responses and 400 stakeholder/shareholder responses) were collected from major sites, including Bodh Gaya, Nalanda, Rajgir, Vaishali, and East Champaran, around the Buddhist Circuit in Bihar. For the proper assessment, a multi-stage stratified and purposive sampling technique was used to select respondents. In the first stage, prominent sites within the Buddhist Circuit were identified based on tourism activity and proximity to Scheduled Caste populations. In the second stage, villages within a 5–10 km radius of these sites were purposively selected. In the third stage, stratified random sampling was employed to select households from Scheduled Caste communities within each village. A total of 800 tourists and stakeholders were surveyed to ensure both coverage and diversity across the study area.

The primary data collected from the field and compiled from the secondary sources were first entered and organized in Microsoft Excel, then imported into SPSS (Statistical Package for the Social Sciences) for detailed statistical analysis. This combination of quantitative and spatial analysis provided a robust foundation for interpreting tourist perspectives and stakeholder views on the changing scenarios of the Buddhist Circuit in Bihar. The data were used to develop various models and diagrams using ArcGIS, QGIS, and other techniques to convert the compiled data into appropriate maps, models, and visualizations.

BUDDHIST CIRCUIT AND ITS SURROUNDING AREAS IN BIHAR

Figure 1 : Buddhist circuit and its surrounding areas.

1. Tourists' Perception and Recognition

The Buddhist Circuit in Bihar is emerging as one of the most fascinating destinations compared to other circuits in Bihar and across India. The state is blessed with numerous heritage and natural sites that hold vast potential for development and tourist attraction (CDP, Bodh Gaya, 2020). The rich cultural heritage of Bihar presents numerous opportunities for tourism, and many unexplored destinations appeal not only to leisure travelers but also to those interested in spiritual tourism and scholarly pursuits (Jauhari, 2010). Tourists' perceptions and recognition of the sites are crucial to understanding tourism trends and patterns in the state. Recently, emphasis has been placed on understanding human nature, as this understanding is vital for better comprehending tourists (or pilgrims) at the individual level and for advancing the tourism industry, especially in the context of sustainable tourism (ST). This paradigm shift calls for a reinterpretation of human behavior, acknowledging contextual and contemporary influences and recognizing the growing effects of "thought pollution" or "thought narrowness" (cf. Fennell and Cooper, 2020). This study explores various ideas, initiatives, and facilities being introduced or developed to attract tourists from around the world. It investigates these elements through tourists' perceptions, which are discussed in the following sections.

Table 1. Purpose of Tourist Destination in Buddhist Circuit

Motive for Pilgrimage	Tourist				Total	
	Domestic Tourist		Foreign Tourist			
	No.	Percent	No.	Percent	No.	Percent
Religious Affiliation	64	53.3%	131	46.8%	195	48.8%
Ritual Ceremony	21	17.5%	56	20.0%	77	19.3%
Family Excursion	12	10.0%	21	7.5%	33	8.3%
Business Purpose	2	1.7%	8	2.9%	10	2.5%
Tour and Recreation	14	11.7%	37	13.2%	51	12.8%
Conference Participation	2	1.7%	3	1.1%	5	1.3%
Others	5	4.2%	24	8.6%	29	7.3%
Total	120	100.0%	280	100.0%	400	100.0%

Source: *Field Survey, November 2024-January 2025 (Total No. of Respondent-400, Domestic Tourists: 120, Foreign Tourists: 280)*

Table 1 illustrates the purposes of domestic and foreign tourist destinations within the Buddhist Circuit. It explores the tourist view of the motive of pilgrimage in the Buddhist Circuit. The data reveal that 53.3% of domestic and 46.8% foreign tourists visit this place due to their religious attachment and affiliation, while 17.5% and 20.0% come to this place for ritual ceremonies such as Buddha Mahatsav, Tripitakan Chanting, the holiness preaching of the Dalai Lama and Karmapa, etc. whereas 10 % of domestic and 7.5 % of foreign tourists enjoy the family excursion. Very few come to this place only for an academic and seminar visit to this circuit. The overall outcome shows that nearly half (48.8 %) of the tourists visit Bihar's Buddhist Circuit for religious reasons while 19.3% come for rituals and 12.8% for recreation.

Smaller groups visit for family trips (8.3%), business (2.5%), or conferences (1.3%). This shows that most jobs like guides, homestays, hotels, restaurants, or sellers of ritual items, depend on religious tourism. With few business travelers, the economy stays rooted in local, community driven work.

Table. 2: Participation in the Religious Ceremonies at the Sites

Buddhist Ceremony	Tourist				Total	
	Domestic Tourist		Foreign Tourist			
	No.	Percent	No.	Percent	No.	Percent
Buddha Mahotsav	18	15.0%	39	13.9%	57	14.3%
Teaching of Dalai Lama	20	16.7%	41	14.6%	61	15.3%
Preach of Karmapa	6	5.0%	19	6.8%	25	6.3%
Dhamma Yatra	13	10.8%	29	10.4%	42	10.5%
Other Rituals	63	52.5%	152	54.3%	215	53.8%
Total	120	100.0%	280	100.0%	400	100.0%

Source: *Field Survey, November 2024-January 2025 (Total No. of Respondent-400, Domestic Tourists: 120, Foreign Tourists: 280)*

Table 2 shows the tourists' perceptions and participation in the religious ceremonies at the sites in the Buddhist Circuit. There are many religious ceremonies and Mahotsav are being celebrated at the sites. These are Buddha Mahotsav, Teachings of Dalai Lama, Preach of Karmapa, Dhamma Yatra, and other rituals. The study shows that the flow of domestic tourists mainly comes to enjoy the place on weekends and holidays. The data reflect that domestic tourists visit these sites for Buddha Mahatsav (15.0 %), Teachings of Dalai Lama (16.7 %), during Preach of Karmapa (5.0 %), Dhamma Yatra (10.8 %), whereas foreign tourists participate in 13.9 % in Buddha Mahautsav, 14.6 % in Teaching of Dalai Lama, and 10.4 % in Dhamma Yatra. Most of the Foreign Tourists also visit these sites only for entertainment with family and friends, group enjoyment in tour packages, as well as academic and research purposes.

The overall data reflects that over half (53.8%) of tourists join “other rituals”, while smaller groups attend teachings by the Dalai Lama (15.3%) or Buddha Mahotsav (14.3%), followed by Dhamma Yatra (10.5%) and the preachings of Karmapa (6.3%). This mix of activities means locals earn by organizing events, selling crafts, or sharing cultural stories. Such diversity helps preserve traditions and creates jobs for artisans, boosting the informal economy.

Table. 3: Familiar to the Developmental Strategy of Buddhist Circuit

Awareness about the Buddhist Circuit	Tourist				Total	
	Domestic Tourist		Foreign Tourist			
	No.	Percent	No.	Percent	No.	Percent
Already Familiar	62	51.7%	138	49.3%	200	50.0%
Family/Relatives	31	25.8%	70	25.0%	101	25.3%
Books & Guides	4	3.3%	15	5.4%	19	4.8%
Friend or visitor	9	7.5%	28	10.0%	37	9.3%
The Internet	10	8.3%	23	8.2%	33	8.3%
Travel Agency or Packages	4	3.3%	6	2.1%	10	2.5%
Total	120	100.0%	280	100.0%	400	100.0%

Source: *Field Survey, November 2024-January 2025 (Total No. of Respondent-400, Domestic Tourists: 120, Foreign Tourists: 280)*

Summarily, Table 3 illustrates the familiarity with the development strategy of the Buddhist Circuit, as well as awareness about the Buddhist Circuit. The data revealed that 51.7 % domestic and 49.3 % foreign tourists have already remarked on the developmental strategy with important sites in the study area, nearly 25 % known through family/relatives, and 8 % got information through the internet about the sites.

The overall data shows that almost half of the respondents (50%) were already familiar with the sites, primarily through family networks (25.3%), followed by 9.3% from friends and visitors, then 8.3% from books and guides, while only 4.8% relied on the internet. This highlights the significant role of cultural heritage and word-of-mouth in shaping tourism trends. A low dependency on formal channels, such as travel agencies (2.5%), suggests untapped potential to strengthen digital outreach and structured tourism packages. Improving access to diverse information sources could attract broader demographics, fostering inclusive economic growth for local communities.

Table. 4: Tourists' opinion and perception about the destination?

S.No.		Yes		No	
1	Is it your first visit?	361	90.3	39	9.8
2	Choose this tourist destination again?	395	98.8	5	1.3
3	Recommend to others for this site?	367	91.8	33	8.3
4	Do you feel at home at this site?	362	90.5	38	9.5
5	Feel secure and personal safety at this site?	309	77.3	91	22.8
6	Good network to reach the destination?	219	54.8	181	45.3
7	Overall cleanliness & hygiene?	304	76.0	96	24.0

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6	Good network to reach the destination?	219	54.8	181	45.3
7	Overall cleanliness & hygiene?	304	76.0	96	24.0
8	Friendliness of the staff/local people?	250	62.5	150	37.5
9	Is the destination good for nightlife?	318	79.5	82	20.5
10	The good civic amenities	313	78.3	87	21.8
11	Qualities of health services at this site	328	82.0	72	18.0
12	Local market enough to fulfill the tourist demand?	301	75.3	99	24.8
13	Are local stakeholders actively involved in tourism development at this site?	334	83.5	66	16.5
14	Good communication and trust between tourists and residents at this destination?	336	84.0	64	16.0
15	BTMC or Destination Management Authority is committed to preserving and restoring folk identity, culture, and heritage.	326	81.5	74	18.5
16	Problem of traffic congestion at this site?	298	74.5	102	25.5
17	Is the road encroached by footpath shops?	247	61.8	153	38.3
18	Do you participate in the local festivities?	223	55.8	177	44.3
19	Do you celebrate rituals or Bodh Mahotsav?	300	75.0	100	25.0
20	Does the destination have notable historic/heritage/cultural landmarks?	357	89.3	43	10.8
21	Is the local shopkeeper at this tourist destination is friendly towards the guests?	320	80.0	80	20.0
22	Does this tourist destination respect the natural environment	358	89.5	42	10.5

Source: *Field Survey, November 2024-January 2025*

To understand the recent change, the study examined tourists' opinions and perceptions about the destination, gathering key information to assess public safety, security, cleanliness, and hygiene, and actively involved stakeholders in the development and planning perspective. A similar study to foster the growth of spiritual tourism, helping us better understand the behaviours of tourists and the tourism industry from a philosophically grounded perspective (Mitchell and Sarah, 2014). This approach would be valuable for the knowledge-based society emerging in the 21st century, where tourism is still not fully recognized as a significant resource. Geography, therefore, must serve as a bridging and transdisciplinary platform in this context (Fayos Solà and Cooper 2019: 326). Similarly, the study presents a comprehensive perspective that modernization is a process of social change, or a series of processes that are theoretically universal across time and space (Smith, 1973). According to the opinions of tourists and observations of facts, 90 percent of tourists express a desire to visit the site for the first time, and are also very interested in making a return visit, as well as recommending the site to others. Most of the tourists (77 percent) expressed their views about personal safety and security because they said that we always rush in a group as per the tourist package plans. 23 percent of respondents, especially single, couples, and family tourists, expressed concerns about insecurity and the safety of the places; 76% tourists were happy with the improvement in overall cleanliness and hygiene around the sites. They also have appreciated the local people, shopkeepers, and community organisations running programmes like Nalanda Footpath Association, Rajgir Footpath Association, and Buddha Vihar Society (Vaishali), etc, around the sites. 58 percent of tourists express their views about the Buddhist site, which is not good for the nightlife as it has no nightclub, recreational place, police, or help centres. Buddhist sites are always facing a lack of basic utilities and civic amenities. Only 53 respondents expressed their views about the good civic amenities. Most of them were local and domestic tourists. The Buddhist site has many local and seasonal markets during the festival. These market services include local crafts, Handloom and handicrafts, rituals and cultural ornaments, dress, and basic needs of the tourist. Seventy five percent of respondents are satisfied with enough to fulfil the demand of the tourist. Health is an important parameter of socio-economic studies, as 48% respondents agree that health has improved in the last few years, but temporary medical camps are being arranged during ceremonies and festivals. Network and communication are important aspects for the tourist destinations around the site. It has improved over the last decades, and all the sites are well connected through the road network. Many tourists express their views about the pleasure for the betterment of road connectivity to the site, but very few are concerned about the problems caused by Traffic Congestion due to Encroachment of the Route. Nearly seventy five percent of respondents expressed their views about the problems caused by Traffic Congestion in reaching the destination site. Overall, 98% of tourists expressed their views that the destination has notable historic heritage and cultural landmarks.

Table. 5: Tourist Facilities in Buddhist Circuit

S.No	**Tourists Facilities**	Yes		No	
21.1	Hotel and Restaurants	355	88.8	45	11.3
21.2	Parking	341	85.3	59	14.8
21.3	Bank and Currency Exchange	327	81.8	73	18.3
21.4	Public Park	329	82.3	71	17.8
21.5	Rest Rooms	244	61.0	156	39.0
21.6	Night Clubs/Library	213	53.3	187	46.8
21.7	Medical/Health Camp	288	72.0	112	28.0
21.8	Local Guide	295	73.8	105	26.3
21.9	Sufficient Street Light	276	69.0	124	31.0
21.1	Tourist Information Centre	305	76.3	95	23.8
21.11	Sanitary Staff	249	62.3	151	37.8
21.12	Luggage Store	285	71.3	115	28.8
21.13	CCTV Camera	312	78.0	88	22.0
21.14	Shelter Camp	330	82.5	70	17.5
21.15	Wheel Chair for PH	326	81.5	74	18.5
21.16	Travel Agency	278	69.5	122	30.5
21.17	Auto fare Price Chart	257	64.3	143	35.8
21.18	Public Toilet	302	75.5	98	24.5
21.19	Help Desk	245	61.3	155	38.8
21.2	Complain Helpline	238	59.5	161	40.3

Source: *Field Survey, November 2024-January 2025*

Table 5 shows an assessment and perceptions of tourist facilities around different Buddhist sites in the Buddhist Circuit of Bihar. There are some basic facilities and criteria for the observation to understand the changing scenarios and attraction towards the site. Information has been gathered about the hotel and restaurant, parking, currency exchange, medical and public health, street light, sanitary staff, public toilet & help desk, etc. Approx 80 percent of tourists have expressed their views about the pleasure and the good facilities of hotels, parking, currency exchange, public toilets, and wheelchairs for disabled people, particularly in Bodhgaya and Rajgir. More than 60% respondents expressed their satisfaction with the sanitation services, local guides, restrooms, luggage store, and sufficient street lights. Overall, all the basic facilities for tourists have improved in the last decades. Therefore, tourists have increased due to better infrastructure and better conditions.

Table. 6 : Change over the past decade in the Buddhist Circuit

Changes and Development in Bodh Gaya	Tourist				Total	
	Domestic Tourist		Foreigner Tourist			
	No.	Percent	No.	Percent	No.	Percent
Increased tourism	59	49.2%	125	44.6%	184	46.0%
Changes in local traditions and practices	25	20.8%	51	18.2%	76	19.0%
Growth of infrastructure	21	17.5%	59	21.1%	80	20.0%
Cultural Awakening and its Ceremonies	5	4.2%	14	5.0%	19	4.8%
More commercialization	2	1.7%	11	3.9%	13	3.3%
No significant changes	8	6.7%	20	7.1%	28	7.0%
Total	120	100.0%	280	100.0%	400	100.0%

Source: *Field Survey, November 2024-January 2025 (Total No. of Respondent-400, Domestic Tourists: 120, Foreign Tourists: 280)*

The changing scenario in the Buddhist Circuit is an important aspect of the development. It shows the government initiatives and the progressive path of development. Recently, many initiatives have been taken for the development of the Buddhist Circuit in Bihar with a better infrastructure road network and connectivity. For these purposes, domestic and foreign tourist perception has been studied. Table 6 reveals that 49.2% of domestic and 44.6% of foreign tourists expressed their view that the tourism industry has developed and attracted a large no of tourists over the last decade in the Buddhist Circuit in Bihar. About 17 % domestic and 21 % foreign tourists expressed that it became possible due to the growth in infrastructure with better connectivity and road network.

In Table 6, the overall data reveal that 46% of respondents observed growth of tourism, while 19% noted shifts in local traditions, reflecting socio-cultural impacts. Infrastructural growth (20%) aligned with economic opportunities but low cultural awakening (4.8%) hint at commercialization risks. Such trends shape livelihoods, balancing income generation with preserving the region's cultural identity around the Buddhist Circuit in Bihar.

Conclusion

Bihar is the sacred land of several Buddhist sites, which is not only a testament to the rich cultural heritage but also a place of important destinations for tourist attractions. The Buddhist circuit in Bihar is emerging as the most fascinating destination compared to other circuits in Bihar and India. The basic utilities and infrastructure, like hotels and restaurants, parking, facilities of international bank, and currency exchange, public park, medical/health camp, and sufficient street light, modernization of the tourist information centre, sanitary staff and services, tour and travel agencies, help desk, complain helpline, wheel chair for disabled people, and participation in the ritual ceremonies, etc have slightly improved as compared to the past. Therefore, it has reflected positive perceptions of tourists about these sites. That's why the influx of tourists has also increased in the Buddhist Circuit in Bihar.

Acknowledgement and Declaration

It, hereby declare that the research paper on **An Assessment of the Tourist Facilities and Changing Scenarios in the Buddhist Circuit in Bihar'** is an outcome and Bonafide work under the ICSSR funded minor research project (Sanction No. ICSSR/RPD/MN/2023-24/SC/95) 'Socio- Economic Changes around Buddhist Circuit in Bihar and its Impact on Livelihood on Scheduled Castes' under the supervision of Project Director-Dr. Pintu Kumar from 1st April 2024 to 31st March 2025.

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Prof. R. Gauntia Young Geographer Award, 28 Oct. 2024

ANALYSIS OF RAINFALL TRENDS AND DROUGHT OVER BAGHMATI-ADHWARA RIVER BASIN (1901-2022)

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ABSTRACT

Drought is a natural calamity related to water shortage due to a prolonged delay in precipitation, which harms important ecological and hydrological systems. India's climate is highly dynamic, and large parts of the country experience repetitive droughts. In North Bihar, the Baghmati–Adhwara River Basin is a doab region that is hydrologically dynamic and faces dual challenges of hydrometeorological disasters, specifically floods and droughts. Identification of droughts is important for better planning and managing a river basin's water resource systems, and it is also helpful in mitigating the effects of climate change. This study aims to find out the rainfall trend using the Modified Mann-Kendall (MMK) test and Sen's slope indicator and identify drought severity through the Standard Precipitation Index (SPI) and Rainfall Anomaly Index (RAI) in the Baghmati-Adhwara River Basin for the period of 1901-2022.

The study finds that rainfall has been decreasing over the entire region, with significant decreasing trends in all districts (except Sheohar). The SPI values indicate high occurrences of mild drought and few incidences of severe drought, especially during the last two decades. The rainfall anomaly index exhibits high variability, with a discernible shift towards negative anomalies mid-2000s onwards. This study will help to develop efficient water resource management strategies for the basin as well as improve understanding of regional drought trends.

Keywords: *Drought, MMK Test, RAI, Rainfall Trend, SPI, Variability*

Introduction

During the past few decades, extreme events have attracted the interest of the public and scientific community due to their tendency toward variations in intensity and frequency. Droughts are one type of extreme event that attracts attention because of their adverse impact on ecological as well as hydrological systems (Chandrasekara et al., 2021). Drought is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually

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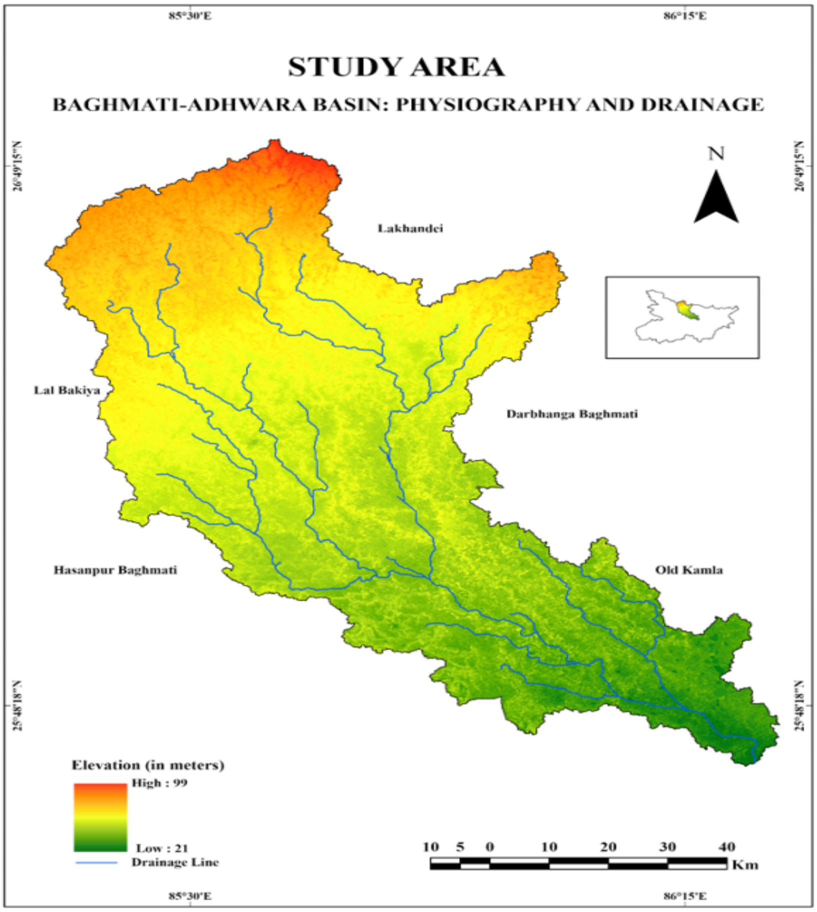
characterized in terms of its spatial extension, intensity, and duration (Ministry of Agriculture 2009). It is one such complicated natural calamities that negatively impact all areas of society and the environment —(Pathak and Dodamani, 2020). Effects of the drought have been observed in almost every climatic region on Earth (Wilhite 2000). A decrease in precipitation for a prolonged period, such as a season or a year, is the primary cause of droughts, which can occur in almost every climate zone, including high as well as low rainfall areas (Mishra and Singh, 2010). Mainly, droughts are of three types: meteorological, agricultural, and hydrological droughts (Zargar et al., 2011). Meteorological droughts are characterized by prolonged periods of low precipitation, while hydrological droughts are characterized by their effects on the hydrological cycle, including abnormally low stream flows, low lake and reservoir levels, and deeper groundwater levels. A lack of precipitation causes a meteorological drought, which in turn affects soil moisture content known as agricultural drought (Tallaksen and Lanen 2024).

Across the world, there have been numerous droughts in the recent past(Khan et al., 2020). The droughts in East Africa (2010–2011), Texas (2012), the United States Central Great Plains (2012), and California (2012–2015) are a few examples(Hao et al., 2018). Global warming has a direct influence on changes in precipitation and the hydrological cycle (Sharma 2019). India's drought has been studied since the 1960s, and it was discovered that upper tropospheric blocking ridges over East Asia caused extended "breaks" in the southwest monsoon, which led to severe summer droughts across the Indian subcontinent (Raman and Rao 1981)Zhang et al. 2017; . Many scientific studies have been carried out to explore drought in Himalayan countries using the Mann-Kendall test for trend analysis, SPI and SPEI for drought assessment, and Pearson Correlation Coefficient and Simple Linear Regression for evaluating SPI and SPEI (Akter et al. 2023; Chandrasekara et al., 2021; Hoque et al., 2020). Many scholars have analysed the droughts using indices standard precipitation index (SPI) and the standardized precipitation evapotranspiration index (SPEI) (Ünal 2023; Alkan and Tombul 2022; Wei et al. 2021). Sarkar (2022) studied the trend of floods and droughts in the Godavari River basin using the Standardized Precipitation Evapotranspiration Index (SPEI), Mann-Kendall's test, and Sen's slope. Singh et al. (2024) analyzed drought across the Harohar-Punpun Basin using RAI and SPI.

Bihar, an eastern state of India, is highly vulnerable to hydro-meteorological disasters. Even though the North Bihar plain receives an abundance of rainfall, drought conditions arise when annual rainfall is even 25% below average. The issue of drought and floods frequently exists at the same time (Singh et al., 2014). Singh et al. (2022) conducted a study on the evaluation of drought in South Bihar and found that the probability of agricultural drought occurrence was high. Bihar experiences a notable decrease in rainfall during the monsoon. Also, soil moisture levels in Central Bihar have been impacted by an increase in dry spells during the winter and post-monsoon seasons (Sharma et al., 2025). Prasad (2019) used SPI to identify droughts in Bihar, and the analysis revealed that there were instances of drought in the state of Bihar from 2000 to 2017.

The present study aims to analyze drought and rainfall trends across Baghmati-Adhwara River Basin, which is situated in northern Bihar, using RAI, SPI, and MMK tests. Baghmati-Adhwara River Basin is a doab region, and the economy of this region is mainly based on agriculture and allied activities, which are dependent on the timely availability of rainfall. So, accurate information on long-term rainfall trends is necessary for the sustainable use of water resources.

Study Area



***Source :** SRTM DEM*

Figure 1 : Study Area

The Baghmati River basin lies in the Himalayan foreland basin, falling under the Indian state of Bihar and Nepal. The Geographical location of the study area is 25º41'54.894"N to 26º52'36.78" N latitude and 85º37'28.20"E to 86º20'38.936"E longitude. The Baghmati River rises in Nepal's Shivpuri Mountain and forms a basin of about 8848 square kilometres. Its entire length is 589 km, of which 394 km are in Bihar and the remaining 195 km are in Nepal.

Lal Bakiya and Hasanpur Baghmati form the right bank tributaries, while Lakhandei, Darbhanga Baghmati, and Old Kamla form the left bank. Budhi Gandak Basin lies in the west, while on the east side, Adhwara basin emerges from Nepal, the Himalayas in the north. In the south of the Himalayan front in the upper reaches, the river displays a braided pattern.

It passes through the Indian soil in the districts of Sitamarhi, Sheohar, East Champaran, Muzaffarpur, Darbhanga, Samastipur, Khagaria, and Begusarai. The average annual rainfall in the basin is about 1255 mm. The Baghmati River basin experiences nearly uniform rainfall from the Southwest Monsoon, contributing to the high sediment load and frequent overbank flooding in the region. The Baghmati plains frequently face overbank flooding due to high annual and decadal rainfall variability and periodic elevated discharge.

Objectives

- To identify the intensity of drought in the Baghmati-Adhwara River Basin.
- To detect the trends of rainfall and patterns of variability in the Baghmati-Adhwara River Basin.

Research Questions

- What is the intensity of drought over the Baghmati-Adhwara River Basin?
- What are the trends and patterns of rainfall variability in the study area?

Data Sources and Methodology

Secondary sources of climate data were used in this study. The mean monthly rainfall data for the districts of Baghmati-Adhwara River Basin were obtained from the India Meteorological Department for the period 1901-2022. The annual rainfall for each district was calculated from the monthly rainfall data. The rainfall database gaps were filled using an interpolation method. The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) of the study area was acquired from the United States Geological Survey (USGS) with a spatial resolution of 30 meters.

After acquiring data, the Modified Mann-Kendall test analysed the rainfall trend, while Sen's slope method was employed to calculate the annual rate of change in the rainfall. The Standardized Precipitation Index (SPI) 12 was used to identify droughts, while the Rainfall

Anomaly Index (RAI) analysed the variability in rainfall patterns. SPI is the most widely used indicator worldwide for identifying and characterizing meteorological droughts (Wang et al., 2022). The value of SPI varies between -2 to +2, where the negative value indicates drought-like conditions and the positive value indicates wet conditions –(Aryal et al., 2022). The value of RAI varies between -4 to +4; values greater than 0 indicate above-normal rainfall and values less than 0 indicate below-normal rainfall. After the computation of RAI values for each district, graphs have been prepared to show the shifting pattern of rainfall using MS Excel.

Results and Discussion

The results of SPI, RAI, and MMK tests show the overall decreasing rainfall trend in the entire Baghmati-Adhwara River Basin, specifically in the last two decades; therefore, droughts are occurring more frequently.

Standardized Precipitation Index (SPI)

Quantifying the precipitation deficit is the key feature of SPI that shows how drought has affected the availability of water in various water bodies. The SPI result shows increasing drought intensity over the Baghmati-Adhwara River basin. The SPI values indicate that, particularly in the past 20 years, there have been many instances of mild drought and few instances of severe drought in the study area.

The SPI results indicate continuous drought years in Darbhanga (Fig.2) from 1927-33 (except 1931), mild wet periods from 1944 to 1948, and a mild to severe drought period between 1989-94 and 2007-17 (except 2012 and 2015). Madhubani (Fig.3) experienced a dry period from 2001 to 2017 (except 2005 and 2015), indicating that Madhubani has been facing water scarcity for the past two decades. Sitamarhi (Fig.4) also went through mild to moderate drought periods during 2003-17 (except 2005,2008, and 2015), while mild to moderate wet periods occurred from 1951 to 1956 and 1969 to 1974. Fig.5 illustrates that Sheohar had a mild to moderate wet period from 1936 to 1948, while mild to moderate drought in the last decade (2006-2017). In the Samastipur (Fig.6) district, a continuous wet period can be seen from 1934-1938. The results show that, except for 1967, there was a drought from 1962 to 1969. Analysis revealed that Samastipur experienced a prolonged drought after 2006. Muzaffarpur (Fig.7) remained dry from 1928 to 1930, mild wet during 1934 to 1936, and it experienced a mild drought from 1987 to 1993. After 2006, Muzaffarpur witnessed continuous dry years with varying degrees of drought intensity. In 2014, Sitamarhi, Sheohar, and Muzaffarpur experienced severe drought, while in 2016, all the districts of the Baghmati–Adhwara River Basin faced severe drought. The SPI values indicate a high occurrence of mild to moderate drought and a few incidences of severe drought, especially during the last two decades in the study area.

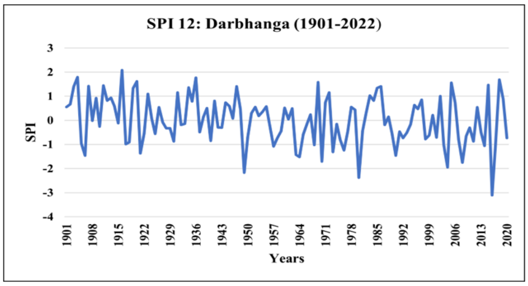


Figure 2

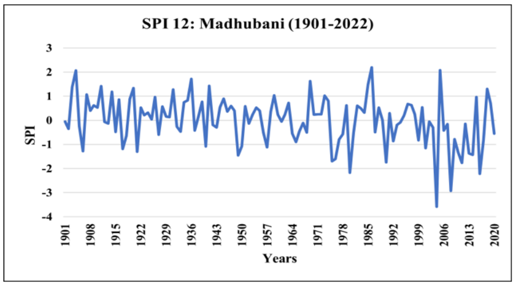
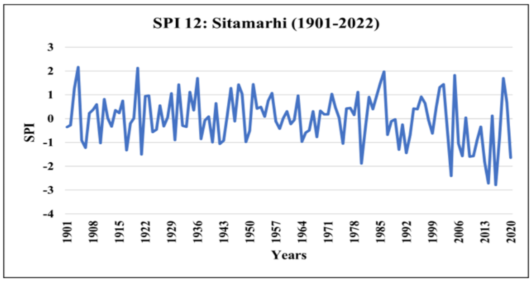


Figure 3



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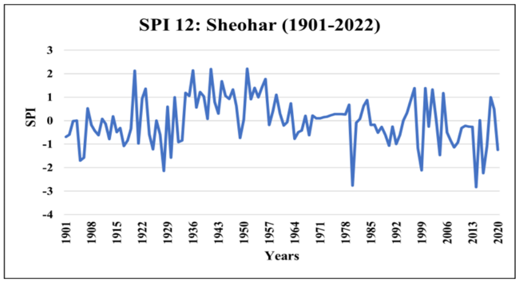

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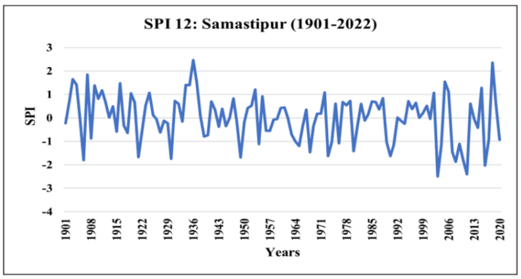

Figure 6

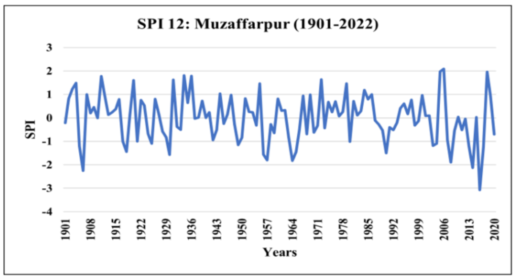

Figure 7

Source: *Prepared by author.*

Rainfall Anomaly Index (RAI)

To assess the pattern of rainfall variability, RAI has been used in this study. The RAI result shows high rainfall pattern variability over the Baghmati-Adhwara River Basin. After 2005, the rainfall pattern of the entire region shifted towards negative anomalies, which indicates a potential shift in the rainfall pattern of these districts. The result shows the highest rainfall pattern shift in Darbhanga (Fig.8) and Madhubani (Fig.9) districts. In Sitamarhi, Sheohar, and Samastipur. (Fig.10-12), rainfall pattern is also shifting towards negative anomalies, but less than the above two districts. In Muzaffarpur (Fig.13), this shift is the least among all these districts. There appears to be a trend toward more negative anomalies in recent years (from around 2010 to 2022), reflecting a noticeable shift in rainfall patterns over the study area.

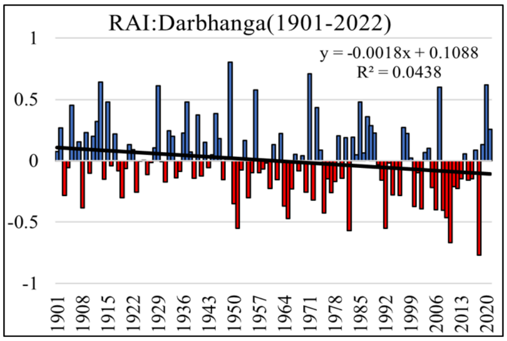

Figure 8

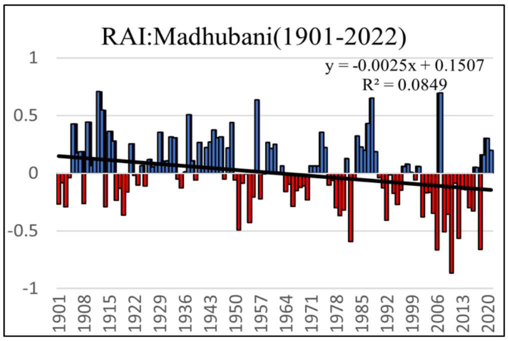

Figure 9

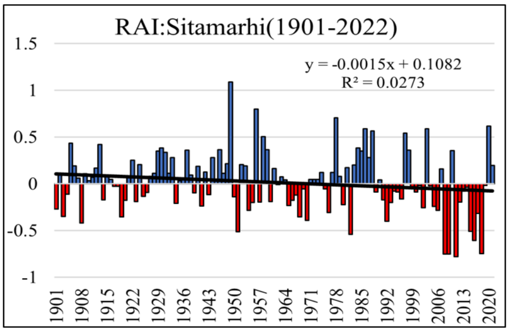

Figure 10

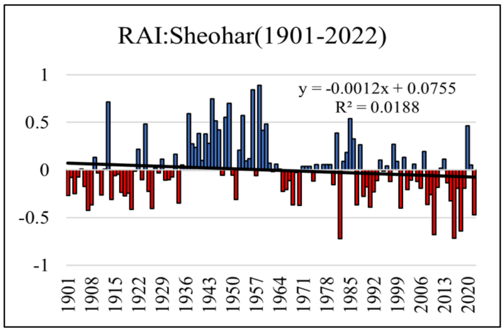

Figure 11

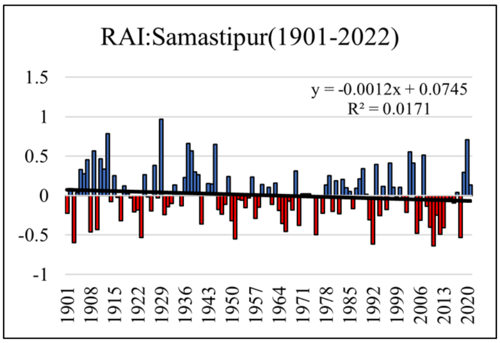

Figure 12

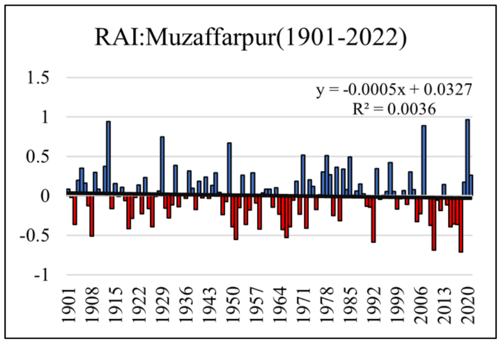

Figure 13

Source: *Prepared by author.*

Modified Mann-Kendall (MMK) Test

The Modified Mann-Kendall (MMK) test results are presented in Table 1. Z-score shows the rainfall trend from 1901 to 2022 over the study area. The results found a decreasing rainfall trend in the Baghmati-Adhwara River Basin.

Table 1: Result of Modified Mann-Kendall Test			
Districts	**Z score**	**Sen Slope (Qs)**	**Interpretation**
Darbhanga	**-3.44**	**-2.31**	**Significant decrease**
Madhubani	**-3.07**	**-2.33**	**Significant decrease**
Sitamarhi	**-2.05**	**-1.37**	**Significant decrease**
Sheohar	**-0.48**	**-0.83**	**Insignificant decrease**
Samastipur	**-2.05**	**-1.51**	**Significant decrease**
Muzaffarpur	**-2.12**	**-1.22**	**Significant decrease**

Source: *Prepared by author.*

There is a significant decreasing trend of rainfall in Darbhanga, Madhubani, Sitamarhi, Samastipur, and Muzaffarpur, while an insignificant decreasing trend of rainfall in the Sheohar district. Table 1 also shows the Sen's Slope, which indicates the slope magnitude for each district from 1901 to 2022 for 122 years. The Sen's Slope value for Madhubani district is -2.33 mm/year, which is the highest among all districts. It means Madhubani is experiencing a loss of one rainy day each year, while in Sheohar the Sen's Slope value is -0.83, which is the lowest among all districts of the study area, but it is also showing decreasing rainfall. The Sen's Slope value of all six districts, Darbhanga, Madhubani, Sitamarhi, Sheohar, Samastipur, and Muzaffarpur, found decreasing rainfall rate at 2.3mm, 2.3mm, 1.4mm, 0.8 mm, 1.5mm, and 1.2 mm per year, respectively.

Summary and Conclusion

The present study aimed to detect the variability of rainfall trends and patterns in the Baghmati-Adhwara River Basin from 1901 to 2022 using SPI, RAI and MMK tests. The Baghmati-Adhwara River Basin is a critical geographical region that is hydrologically dynamic and faces dual challenges of hydrometeorological disasters, specifically floods and droughts. Due to the vulnerability of hydrometeorological disasters in this region, it is important to study the rainfall trend and pattern of this area. The result of the MMK test reveals a decreasing rainfall trend in the entire study area, with a significant decreasing rate in all five districts except Sheohar. The Sen's Slope values for Darbhanga, Madhubani, Sitamarhi, Sheohar, Samastipur, and Muzaffarpur indicate a decline in rainfall rates of 2.3mm, 2.3mm, 1.4mm, 0.8mm, 1.5mm, and 1.2mm annually, respectively. This implies that both Darbhanga and Madhubani are experiencing a loss of one rainy day each year, which is a major concern. The SPI values show a high frequency of mild to moderate drought and a low frequency of severe drought, especially during the last two decades over the Baghmati-Adhwara River Basin. The RAI shows periods of high variability and indicates a potential shift in rainfall patterns towards negative anomalies.

Considering the declining rainfall trend, it is estimated that in the forthcoming years, this region will face more drought conditions. As large parts of the region's economy are based on agriculture and allied activities, such as horticulture, aquaculture, and paddy cultivation, which will suffer greatly from persistent drought. If rainfall continues to decrease, stream flow will also decrease, affecting the ecohydrology of wetlands and lakes in this region. Over time, this will damage the breeding grounds for bird species and the aquatic ecosystems of wetlands and lakes. Also, the people's livelihood will be affected, and this will lead to out-migration. Therefore, it is essential to promote rainwater harvesting, sustainable use of water, and improvement in agricultural practices. This study will improve understanding of the regional drought as well as rainfall trends and help in the formulation of effective water resource management strategies for the basin.

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GENERAL SECRETARY REPORT

On the Auspicious Occasion of the XXVI Annual Conference and National Seminar
of
The Association of Geographers, Bihar and Jharkhand
October 11-12, 2025
P.G. Department of Geography, V.B. University, Hazaribag, Jharkhand

Hon'ble Chief Guest and Guest of Honour of today's inaugural session of 26th Annual Conference cum National Seminar, Chief Patron, Patron, President, Past Presidents, President Elect of the AGBJ, Convener, other dignitaries on the dais, fellow delegates, Life Members & Annual Members of the Association, Invited Guests, Students, Media Persons, Ladies and Gentlemen.

I am standing before you to present my fourth General Secretary report of the overall activities of the association. It is a matter of great privilege and honour for me to present this report on the occasion of the 26th Annual Conference cum National Seminar under the auspices of the Association of Geographers, Bihar and Jharkhand, which is being attended by a large number of distinguished scholars and researchers, not only from different parts of the states of Bihar and Jharkhand but also from other Indian states and again not only from geography but also from several other branches of knowledge.

Friends! Our association has now become more than twenty five years old. During these yeas the Association has strengthened, united and organized the geographers of Bihar and Jharkhand. The association itself has been strengthened in respect of life members, financial position and infrastructure facilities. These have been possible due to the active participation by the P.G. Departments and College Departments of Geography of different universities to give an active support in the functioning of the association. These activities helped in increasing the number of life members to 1525. There has been an increase of about 100 life members in less than one year. There has also been an increase in the number of institutional members and annual members.

I am happy to inform the AGBJ family that our financial position is also considerably sound. This financial year also the statement of account of the Association has been certified by the Chartered Accountant and the treasurer will present the balance sheet in the Annual General Body Meeting. Our fixed deposit is Rs. 1101,000/- and balance in SB A/c is Rs. 692,857/- as on 31st March 2025.

The infrastructural facilities of the Association has also improved much during the last few years. Website has been launched and email address created. We are communicating well with such a large number of members through the website of the association. All relevant informations are now available on the website and one can click www.agbj.in for getting any information. You may interact with the association office bearers through the email-agbj2003@gmail.com. and Whatsapp social media. Besides that, you may also interact with the Editor in Chief regarding journal of the association through the email geographicalperspectiveagbj@gmail.com. The PAN Card of the association has been made to facilitate fixed deposit account.

Dear Friends! Various Departments of Geography of the Universities of Bihar and Jharkhand are promoting the subject by organising Seminars, symposium, workshop, invited lectures and other academic activities throughout the year. Department of Geography, Patna University organized a one week training programme for faculty members on 'Remote sensing and GIS' from 29th July to 2nd August, 2025 in collaboration with Enviro Informatics and Solutions, Patna. A special invited lecture on "Architectural Transformations but cultural Utilization of Space Remains" delivered by Dr. S. Memela of Department of Geography, Rhodes University, South Africa on 18.11.2024. P.G. Department of Geography, Patna College and Patna University has organized a special lecture on the occasion of 2nd National Space Day on 23rd August, 2025. Prof. L.N. Ram, Former HOD of Geography and former Vice-Chancellor of Patna University has delivered a special lecture on "The Sun, Star and Planets". Shri Sunil Kumar, Hon'ble Minister of Education, Govt. of Bihar unveiled the statue of Bhugol Ratna Prof. P. Dayal, a legendary academician and founder of P.G. Department of Geography, Patna University in the campus of the Department on 26 September, 2025.

Department of Geography, A.N. College, Patliputra University, Patna organized a special lecture on "Geospatial Courses and Careers in India" delivered by Dr. Jerry Anthony, Associate Professor, Planning and Public Affairs, University of IOWA, U.S.A. on 25 February, 2025. Dr. Gaurav Sikka, Assistant Professor of Geography, A.N. College, Patna has been awarded a research project entitled "Longitudinal Ethnographic Study of Socio-Economic Shifts, Youth Aspirations, Gender Agency and Indigenous Knowledge among Bihar PVTGS in Bihar and Jharkhand" funded by the ICSSR, New Delhi with worth Rs. 1.25 Cr. in August 2025. Dr. Sikka has delivered a keynote talk on "Youth for Sustainable Action in Bihar: Synerging IGU-YECG and AGA-YGWG" in the 4th Asian Young Geographers Workshop held at Yuxi Normal University, China on 29th November to 2nd December, 2024. Department of Geography, College of Commerce, Arts & Science is Empanelled as a knowledge partnership for Urban Biodiversity Studies and City Biodiversity Index in Biological Sciences for biodiversity related studies by Bihar State Biodiversity Board. Dr. Vidya Yadav, H.OD. of Geography has delivered a talk as a resource person on "Livelihood and Occupational Diversification Strategies: A Pathway for Viksit Bharat@2047" at D.A.V. P.G. College, Siwan on 4-5 December, 2024.

The Department of Geography, LNMU, Darbhanga in collaboration with Prabhat Das foundation has successfully organized a national seminar on the occasion of World Soil Day on 5th December, 2025 on the theme "Mithila Ki Bhoomi : Viksit Bharat Ke Sanderb Mein." An invited lecture was delivered by Shri L.D. Mahapatra, Senior Scientist, IMD, Patna on the topic "Modern Techniques of Weather Forecasting" on 4 February, 2025. A 5-day Workshop (From 24th 28th April, 2025) has been organized in the Department on "Analysing Geographical and Statistical Data Using Python Programming Language and MS-Excel". Dr. Manu Raj Sharma, Assistant Professor of Geography of L.N.M.U. has participated in a training programme on "BHUVAN overview" conducted by the National Remote Sensing Centre, ISRO, Hyderabad on 21-23 January, 2025.

The Department of Geography, T.M.B.U., Bhagalpur has successfully organized a multidisciplinary International Seminar on theme "Adoption of Innovation and Sustainable Development : A way to Vikshit Bharat@2047" on April 11-12, 2025. Dr. Prashat Kumar joined as Head of the Department of Geography, T.M.B.U., Bhagalpur on 12 August, 2025 and Dr. Anirudh Kumar, Former HOD of Geography joined as Principal, B.N. College, Bhagalpur.

The Department of Geography, B.R.A. Bihar University, Muzaffarpur has successfully organized a one day seminar on the topic "Tourism in India : Opportunities and Challenges". Prof. Aoop Kumar Singh, of Patliputra University has delivered a keynote speech in this seminar. Dr. Rupa Kumari, Professor of Geography joined as HOD of Geography and Dr. Ida Ella Seema Kerketta, Associate Professor of Geography has elected as a member of senate of B.R.A. Bihar University, Muzaffarpur Prof. Pramod Kumar, Professor of Geography joined as Principal, Nitishwar Mahavidyalaya, Muzaffarpur.

The Department of Geography, Y.N. College, Dighwara, Saran, a constituent unit of J.P. University, Chapra has organized a one-day seminar on the theme "Beat Plastic Pollution" on the occasion of World Environment Day, 2025. Dr. Ramanuj Kaushik, Assistant Professor of Geography, D.A.V.P.G. College, Siwan has been awarded a research project funded by ICSSR, New Delhi on the topic "An Exploratory Study on Livelihood and Occupational Diversification Strategy of Rural Household in Bihar". Prof. Birendra Kumar, Professor of Geography joined as Principal in Jamuni Lal College, Hazipur. Prof. Sanjay Kumar, Jagdam College, Chapra joined as Principal, S.K.R. College, Barbigha, Sheikhpura, a constituent College of Munger University, Munger.

Dr. Ambarish Kumar Rai, Assistant Professor of Geography, V.K.S.U., Ara has been awarded a research project entitled "Socio-economic and Health Assessment of the Jal Jeevan Mission in Rural Bihar: An Empirical Study of Samastipur District" funded by ICSSR, New Delhi in the year 2024-25. P.G. Department of Geography, Maharaja College, Ara under leadership of Prof. Sanjay Kumar, H.O.D of Geography conducted a Primary Survey on socio-economic conditions of the Musahar community in village Chaurai under Udwantnagar block of Bhojpur district during 18-24 March, 2025. Paper entitled "Cyber Geography of Everyday life: A Comparative Study" of Dr. Dweepika S. Singh, Assistant Professor of Geography, Maharaja College, Ara has been selected in the Best Presentation Award Category in International Conference on Literature, Society and the Global Media held on 20-21 September, 2025. Prof. N.K. Palit, Professor of Geography joined as Principal, M.M. Mahila College, Ara and Prof. Nazir Akhtar, Professor of Geography of V.K.S. University, Ara joined as Principal, Anugrah Memorial College, Gaya.

The School of Geographical Studies, Aryabhatta Knowledge University, Patna has organized a series of extra-curricular activities in the campus like– Matribhasha Diwas on February 21, 2025; International Women's Day on March 8, 2025; World Population Day on July 11, 2025 and World Ozone Day on September 16, 2025. A research paper entitled "Understanding air pollution in Bihar: A district level analysis of causes, effects and mitigation strategies" by Dr. Manish Parashar, Assistant Professor has been published in International Journal of Research and Analytical Review (IJRAR).

The Department of Geography, Vinoba Bhave University, Hazaribagh has successfully organized a series of five lectures delivered by eminent Geographers across the country under the Chancellor's Lecture Series Programme. The lectures under this series programme has been organized on 10th, 17th, 21st and 28th of May, 2025. In addition to this Chancellor's Lecture Series, the Department has organized several invited lectures.

Dr. Virendra Kumar, Professor of Geography, Magadh University, Bodh-Gaya has delivered a lecture on "Food Security in India : Constraints ad Possibility" on 5 October, 2024. Dr. Manoj Kumar Sinha, Professor of Geography, Patna University has delivered a lecture on "Tourism : A Resource Potential for the Development of Bihar and Jharkhand". On 16 October, 2024. Dr. Ravi Shekhar, Professor of Geography, CSRD, JNU, New Delhi has delivered a lecture on "Spatial Data Representation by Chotopleth Method" on 9 September, 2025.

The Department of Geography, Kolhan University, Chaibasa, West Singhbhum has been awarded a research Project entitled "A Socio-economic and Cultural Analysis of Changing Inter and Intra-Household Relations in Tribal Communities of Jharkhand" funded by Dr. Ramdayal Munda Tribal Welfare Research Institute, Ranchi in the year 2024. A Workshop was organized in the Department on Qualitative Research Method in December, 2024.

It is our pleasure to inform you that Prof. D.P. Singh, our former President has launched an academic programme under the name of **'Founders and Makers of Modern Geography in India'**. It is an online lecture series whose 65th episodes are completed recently on September 28, 2025. This programme has received warm response from the Indian subcontinent. Now series of edited volumes (Books) are in process of publication, covering lectures delivered on the theme. Prof. D.P. Singh, Director Researches of Institute for Environmental Research and Rural Development (IERARD) became convener of the South Asia Geographers Association (SAGA).

Since our last annual conference held in October, 2024, geography departments of different universities of Bihar and Jharkhand have organised several academic activities both offline as well as online. There are 141 Assistant Professors of Geography have joined in different Universities of Bihar. Several guest faculties and regular teachers have also joined respective geography departments of Bihar and Jharkhand. We seize this occasion to congratulate them and also request them to associate themselves with the Association to carry it forward and to make it an association of new generation geographers. I am sorry to state that due to shortage of time achievements of several geographers of Bihar and Jharkhand in the fields of book writing, receiving awards, attending National and International Seminars, Symposium and Workshops getting promotion, etc., I am not in a position to mention respective names, but I, on behalf of the Association congratulate them and wish to have a bright future.

I, as a General Secretary of the Association request all those life members who have not furnished their email to kindly send the same to the Association through email agbj2003@gmail.com. You are also requested to be a regular follower of our website for any kind of information. All newly recruited teachers in geography are specially requested to come forward to become actively associated with the Association. Your association will give a new generational move to enhance your academic future.

At the end I once again express my sincere thanks to all of you for your kind co-operation and support in running the Association. I am sure that our bond to work together will promote the cause of geography and succeed in establishing geography as an indispensable subject in coming years. We need to work academically on challenging issues in a systematic and scientific way so that stake holders in the field of planning and management may not be able to ignore the importance of Geography.

I hope that your two-day stay at this historical and a city of thousand gardens will be academically very fruitful. At last I owe deep sense of gratitude to the convener, organising secretary and members of organising committee of this Conference cum seminar who have provided all kinds of facilities satisfactorily.

Thanking you all once again.

Jai Bhoogol ! Jai Bihar !! Jai Jharkhand !!!

(Dr. Manoj Kumar Sinha)
General Secretary, AGBJ
email: agbj2003@gmail.com

THE ASSOCIATION OF GEOGRAPHERS BIHAR & JHARKHAND

DEPARTMENTAL NEWS

PATNA UNIVERSITY, PATNA

1. **Joining of new Faculty Members:**

   Dr. Prerna Bharti, Dr. Md. Ashraf, Dr. Pramod Kumar Pandey, Dr. Sudha Kumari, Dr. Anil Kumar and Dr. Meera Thakur joined as Assistant Professors at the P.G. Department of Geography. Dr. Vivek Kumar, Dr. Ram Naresh Prasad, Dr. Ranjeet Kumar, Dr. Anil Kumar Akela, Dr. Rekha Kumari, Dr. Shweta Kumari and Dr. Rakesh Kumar Gond joined as Assistant Professors at Patna College. Dr. Babita Kumari Dr. Rajendra Prasad Jaiswal and Mr. Mohammad Akram joined as Assistant Professors at B.N. College and Dr. Sanwita Shaiwalini joined as Assistant Professor at Patna Women's College.

2. **Activities in the Department:**

   - Special invited lecture of Dr. Sinenhlanhla Memela Faculty Member, Department of Geography, Rhodes University, South Africa - A special invited lecture on "**Architectural Transformation but Cultural Utilization of Space Remains**" was organized on 18.11.2024 (Monday) at 12:30 Noon in the Seminar Hall of the Department of Geography, Patna University, Patna for the benefit of our faculty members, research scholars and students.
   - World Earth Day was celebrated on 22.04.2025 in the Department of Geography, Patna University. On this occasion Sakora pots with grains and water were installed in the campus for birds.
   - P.G. Department of Geography, Patna College and Patna University has organised a Special lecture on the occasion of Second National Space Day on 23 August, 2025. Prof. L. N. Ram, Former HOD of Geography and Former Vice-Chancellor of Patna University has delivered a special lecture on "The Sun, Star and the Planets".
   - Shri Sunil Kumar, Hon'ble Minister of Education, Government of Bihar unveiled the statue of Bhugol Ratna Prof. P. Dayal, a legendary academician and founder of P.G. Department of Geography, Patna University in the campus of the department on 26 September, 2025. Prof. Ajay Kumar Singh, Vice Chancellor of Patna University has presided over the function.

3. **Conference, Seminar, Training Programmes and Workshop organized/ participated:**

   i. **25th Annual Conference & National Seminar of the Association of Geographers, Bihar and Jharkhand -** Department of Geography Patna University organized 25th Annual Conference & National Seminar of the Association of Geographers, Bihar and Jharkhand on the focal theme of " Climate Change, Agriculture Practices and Food Security" on 27.10.2024 & 28.10.2024. The inauguration and Valedictory ceremony was organized at J.P. Held at Anushad Bhavan (Wheeler Senate House) and the technical sessions were organized in the Department of Geography Patna University. The program was inaugurated by Shri Sunil Kumar, Education Minister, Government of Bihar. On this occasion, guest of honor and patron Professor Ajay Kumar Singh, Vice Chancellor, Patna University shared his views and said that when climate changes, the behavior of plants also changes. The guests were felicitated by the convener Prof. Md. Nazim, joint convener Prof. Manoj Kumar Sinha, and organizing secretary Dr. Debjani Sarkar Ghosh. This conference was an important platform for promoting the study of Geography, and to provide an opportunity for exchange of knowledge and experiences among researchers, teachers and students.

   ii. A one week Hands on Training Programme on "Remote Sensing and GIS" has been organised from 29th July to 2nd August 2025 in the collaboration with Enviro Informatics and Solutions.

   iii. Dr. Debjani Sarkar Ghose presented a paper on "Climate Change and Treat to Vector-Born Diseases and Heat Stress in Bihar" in 8th National Association of Geographers, India (NAGI) International Conference organized by Dept. of Geography, Kazi Nazrul University, September 23- 25, 2024 .

   iv. Dr. Debjani Sarkar Ghose presented a paper on "Economic Well- being and Health Status of working Women: A Case Study of Patna M.C, Bihar in International Seminar on Geography for Development: Economy, Society and Environmental Interactions" organized by Department of Geography, Presidency University, Kolkata in association with The Institute of Indian Geographers (IIG), January 27-29,2025.

   v. Dr. Debjani Sarkar Ghose contributed as co-chairperson in International Conference on Recent Trends in Biosciences and Healthcare organized by Dept. of Zoology, Patna University, Patna 22nd -23rd November, 2024.

   vi. Debjani Sarkar Ghose contributed as co-chairperson in 8th National Association of Geographers, India (NAGI) International Conference organized by Dept. of Geography, Kazi Nazrul University, September 23- 25, 2024 .

vii. Dr. Prerna Bharti presented a paper " Sptio- Temporal Analysis of the Changing Electoral Culture of Women in Bihar" at the 35th International Geographical Congress held in Dublin, Ireland,from 24-30 August, 2024.

viii. Dr. Pramod Kumar Pandey presented a paper on "Dense Mineral Variation in Different Geomorphic Units of Barakar: Evaluation of Hinterland" organized by University of Kashmir , Sri Nagar held from 02.09.2025 to 04.09.2025.

4. Publications :

i. Prof. Md. Nazim

- Nazim, M., Islam, S., & Kumari, T. (2024). Agricultural Production of Major Food Crops in West Bengal: A Geographical Analysis, **JIGYASA-An International Multidisciplinary Peer Reviewed and Refereed Research Journal**, ISSN:0974-7648, Vol-17, No-3, pp-27–38.
- Nazim, M. and Nigam, Navneet (2024)- Spatio-Temporal Analysis of crop diversification in North Bihar, India, **The Eternity-An International Multidisciplinary Peer Reviewed and Refereed Research Journal,** ISSN: 0975-8690, Vol. *15,* No.3, September, 2024, pp- 386–399.
- Nazim, M., and Kumar, Vivek (2024)- Climate change and Agriculture in Bihar: Impact and Adaptation Strategy. **The Deccan Geographers**, ISSN: 0011-7269, Vol. 62, No. 10, pp- 248–258.
- Nazim, M., and Kumar, Shubham (2024) - Women Empowerment and Political Participation in India: A Geographical Analysis, **Ayan-An International Multidisciplinary Peer Reviewed and Refereed Research Journal**, ISSN: 2347-4491, Vol- 12, No.-4, pp- 329–343.

ii. Dr. Debjani Sarkar Ghose

- Padmaja, Akansha, Sarkar Ghose D(2025), ' Millets: A resilient Crop in the Changing Climate in Bihar, India,' Indian Journal of Spatial Science, 16(2), pp 72-80, ISSN 2249-3921, EISSN 2249-4316.
- Bharti Prerna, Sarkar Ghose D(2025), "Spatio-Temporal Analysis of the Changing Electoral Culture of Women in Bihar", GEOgraphiaVol. -27, N 58, pp 1-11, ISSN 1517-7793, eISSN -2674-8126.

- Sarkar Ghose D, Niharika Narayan (2024), **'Empowerment of Scheduled Caste Women: A case study of Patna Municipal Corporation Area',** International Journal of Cultural Studies and Social Sciences, Vol. 21, Issue 2, pp 68-75, ISSN 2347-4777.

iii. Dr. Prerna Bharti

- Sikka, G. and Bharti, P. (2025) Nagar Van Yojna A Beacon of hope for urban biodiversity in Bihar, AnugraghJyoti, pp 100 -107, ISSN : 2454-1133
- Bharti P.andSarkarGhose D. (2025) Spatio- Temporal Analysis of the Changing Electoral Culture of Women in Bihar, GEOgraphia, Vol 27, pp. 1-11 ISSN 15177793/2678126
- Sikka, G. and Bharti, P. (2024) Mapping the Spatial Imbalance of Higher Education Institutions in Bihar, Bihar Journal of Public Administration, Vol. XXI, No.2, pp. 839-848 ISSN 0974-2735 (UGC-CARE Group 1)

5. Research Project :

Dr. Prerna Bharti is Project Director in ICSSR funded project. The Title of the Project is “A Longitudinal Ethnographic Study of Socio- economic Shifts, Youth Aspirations, Gender Ageny and Indigeneous Knowledge among Birhor PVTGs in Bihar and Jharkhand” under 2nd Call for ICSSR Longitudinal studies in Social and Human Sciences. The ICSSR has awarded a grant-in-aid of Rs. 1,20,00,000/- for this research project.

PATLIPUTRA UNIVERSITY, PATNA

A. N. COLLEGE, PATNA

1. Joining of new faculty members

i. Dr Deepak Kumar joined as Assistant Professor, on 23.12.2024 being transferred from Dauadnagar College, Daudangar, Magadh University via inter-university transfer.

ii. Dr Amar Kumar, Dr Arun Kumar, Dr Randhir Kumar joined as Assistant Professor (newly appointed by BSUSC).

iii. Dr Prashant Kumar joined as Assistant Professor, on 01.08.2025 being transferred from H. D. Jain College, Ara, Veer Kunwar Singh University via inter-university transfer).

2. Activities in the department:

i. **Dr Suraj Kumar Singh**, Associate Professor and Head, Centre for Climate Change and Water Resource, S.G. V. University, Jaipur, Rajasthan, gave a special talk on "**Harnessing Geospatial Technology for Efficient Natural Resource Management on 20.09.2025.**

ii. PG Department of Geography and **IGU Commission for Young and Early Geographers** organised a special lecture by **Dr Sine Memela**, Senior Lecturer, Rhodes University, South Africa, on the topic "**Transforming Living spaces and Cultural Practices**" on 21.11.2025.

iii. **Dr Raghavswamy Vaddiparli**, Senior Scientist and Deputy Director from the National Remote Sensing Centre, Hyderabad, delivered a special lecture on the topic "**Geospatial courses and Careers in India"** on 25.02.2025.

iv. **Dr Jerry Anthony**, Associate Professor, Planning and Public Affairs, University of IOWA, U.S.A., on the topic "**Empowering Women's Lives through Improved Cookstoves"** on 03.06.2025**.**

v. The department organised a poster competition on 12.07.2025 for World Population Day, showcasing population as both a human resource and a burden on natural resources.

3. Publication details of faculty members:

- **Dr. Vinita Prasad**

i. "Farmland Drainage Water and Suitability Assessment for Groundwater Artificial Recharge with Unconventional Water (GARU)" published in "Hydrosystem Restoration Handbook" Vol. 4, Elsevier Publication.

ii. "Impact of Climate Change on Urban Environment: A Case Study of Patna Municipal Corporation Area" Published in MANAVIKI, An International peer Reviewed and Referred Journal of Humanities & Social Sciences, ISSN: 0975-7880, Vol. XVI, No. 2, July-December, 2024, p.p.1-20.

iii. "सिवान जिले से मध्य पूर्व के देशों में प्रवास जनित रोजगार के अवसर का विकास एक भौगोलिक अध्ययन" published in International Journal of Research and Analytical Reviews (IJRAR)/ IJRAR.ORG: An international Open Access, Peer-reviewed, Referred journal, E-ISSN:2348-1269, P-ISSN:2349-5138, September'2024, Volume:11, Issue:1, p.p. 572-582.

- **Dr. Bhawana Nigam**

i. Stream morphology changes under climate change, Chapter 12 - Hydro System Restoration Handbook, Elsevier, 2025, Pages 161-169, ISBN 9780443298028, https://doi.org/10.1016/B978-0-443-29802-8.00012-1.

ii. Water Resources, Food Security, and Climate Change Nexus: Challenges and Solutions for a Sustainable Future, Anughrah Jayanti, Peer Reviewed Journal, 2025, pg. no-87- 99, ISSN: 2454-1133.

- **Dr. Gaurav Sikka**

i. A land–water–energy–greenhouse gas nexus framework informs climate change mitigation in agriculture: A case study in the North China Plain, *Geography and Sustainability*, Vol. 100354, ISSN 2666-6839, 2025, https://doi.org/10.1016/j.geosus.2025.100354(Scopus indexed, Impact Factor 8.0)

ii. Mapping the Spatial Imbalance of Higher Education Institutions in Bihar, *Bihar Journal of Public Administration*, Vol. XXI, No.2, pp. 839-848 ISSN 0974-2735 (UGC-CARE Group 1)

iii. Site Suitability Analysis for Municipal Solid Waste Management System in Ranchi City using AHP: A Multi-Criteria Decision Approach, *Environmental Quality Management,* Vol. 34, Issue 1, e22312 https://doi.org/10.1002/tqem.22312 (Scopus indexed, Impact Factor 1.5)

- **Dr. Deepak Kumar**

i. Beyond the Blackboard: Impact of COVID-19 Pandemic on Rural Bihar with Special Reference to Education in Aurangabad District, Chapter 8, The Silent Fallout: Human Cost of a Global Crisis, 2025, Page No. 56-61, ISBN 9789363853492, University Book House (Pvt.) Ltd. https://www.ubhjaipur.com/product/the-silent-fallout-human-cost-of-a-global-crises/

- **Dr. Prashant Kumar**

i. Research design: a key to a systematic approach of scientific research, 2024, Indian Journal of Psychology, 15, pg.58-67, 2024, 0019-5553 (ISSN).

4. Research Projects, Grants and Academic Collaborations, etc

- **Dr Gaurav Sikka** has been awarded a longitudinal research project entitled "Longitudinal Ethnographic Study of Socio-Economic Shifts, Youth Aspirations, Gender Agency, and Indigenous Knowledge among Birhor PVTGs in Bihar and Jharkhand", funded by **the Indian Council of Social Science Research** (ICSSR), Ministry of Education, Govt. of India, worth 1.25 Crores (August 2025 onwards)
- Dr Gaurav Sikka led **the International Collaboration Project** on "Transforming Living Practices and Cultural Practices" with Rhodes University, South Africa (December 2024).

5. Conference, Seminar, Training Programmes, and Workshop organised/ participated in

- **Dr. Gaurav Sikka**

i. Keynote Talk: "Role of Geography in Planning and Development" in National Science Day Celebration at **National Atlas and Thematic Mapping Organisation (NATMO), Kolkat**a, 28th February 2025.

ii. Keynote Talk on "Youth for Sustainable Action in Bihar: Synergising-IGU-YECG and AGA-YGWG" in 4th Asian Young Geographers Workshop at **Yuxi Normal University, China** 29th November-02 December 2024

- **Dr Deepak Kumar**

i. Participated in Multi-Disciplinary **Refresher Course on "Indian Knowledge System for Inclusive and Sustainable Development: Theory, Practices and Relevance of Higher Education."** organized by UGC-Malaviya Mission Teacher Training Centre (MMTTC), National Institute of Educational Planning and Administration (NIEPA), New Delhi with Visva-Bharati, Santiniketan, West Bengal, in August 2025.

ii. Completed Faculty Development Program on "INDIAN KNOWLEDGE SYSTEMS:AN INTRODUCTION" organized by Gokul Global University, Siddhpur, Gujarat in collaboration with Nucleus of Learning and Development (NLD) August, 2024,

iii. Completed Faculty Development Program on "INDIAN KNOWLEDGE SYSTEMS: AN INTRODUCTION" organized by B.R.B College of Commerce, Raichur, Karnataka in collaboration with Nucleus of Learning and Development (NLD), November 2024.

iv. Participated as a Resource Person in the National Seminar on "Globalization: Challenges and Opportunities in Polity, Social Justice and Sustainable Development" Organized by S. N. Sinha College, Warisaliganj, Magadh University, on 25th September, 2024.

v. Participated as a Resource Person in the National Seminar on International Women's Day and delivered lecture on the topic "Relevance of Women in the Progress of Nation". Organized by Daudnagar College, Aurangabad, Magadh University, on 8th March, 2025.

- **Dr Arun Kumar, Dr Randhir Kumar and Dr Amar Kumar**

i. 9th FIP from MMTC Patna University, from 19.08.2025 to 18.09.2025

- **Dr Prashant Kumar**

i. "Health Geography: A Critical Contemporary Spatial Approach in Social Sciences" on 2024-10-28 at 25th Annual Conference & National Seminar Organized by Department of Geography, Patna University, Patna, Bihar

COLLEGE OF COMMERCE, ARTS & SCIENCE, PATNA

1. Joining of New Faculty Members: (Assistant Professor, Bihar State University Commission)

1.	Dr. Monika Kumari	2.	Dr. Vijay Kumar
3.	Dr. Md. Tasnimuddulah	4.	Dr. Anita Singh

2. Publications:

i. Ranjana (2024), *An Initiative for Rural Revitalization in Bihar: Development of Rural Areas as a Tourist Destination*, Geographical Perspective, Vol. 25, ISSN 0970-809X, pp-154-174.

ii. Yadav, V., Mishra M. & Gavaskar K. (2025), "*The Built Environment and Public Health in India: Opportunities, Challenges and Future Pathways"*, Part of Book series**:** New Frontiers in Regional Science: Asian Perspective (NFRSASIPER, Volume 85), Springer Nature Singapore Ltd.

iii. Kumari, S. and Yadav, V. (2025). *"Mate Selection, Caste Norms, and Female Decision-Making in Indian Marital Systems: A Systematic Review"*. Asian Journal of Advanced Research and Reports, 19 (7): pp-176-93. https://doi.org/10.9734/ajarr/2025/v19i71090.

3. Research projects/Grants and Academic Collaboration:

I. *Department of Geography, College of Commerce, Arts & Science is Empaneled as a knowledge partnership for Urban Biodiversity Studies and City Biodiversity Index in Biological Sciences for biodiversity related studies by Bihar State Biodiversity Board.*

4. Conference/Seminar/training programme and workshop organized:

i. Dr. Vidya Yadav, Organized ten Days Workshop on Research Methodology in College of Commerce, Arts & Science, Patna during 20th-September to 1StOctober, 2024.

ii. Dr. Vidya Yadav was an Resource Person in Ten Days Workshop on Research Methodology in College of Commerce, Arts & Science, Patna during 20th-September to 1StOctober, 2024.

iii. Presented Paper by Dr. Vidya Yadav entitled “Resilience of Building Under a Changing Climate: An Assessment of Risk Analogy” in 25th Annual Conference & National Seminar of AGBJ Organized by the Department of Geography, Patna University, Patna on October 27-28, 2024 at the Department of Geography, Patna University, Patna.

iv. Presented Paper by Dr. Rashmi Ranjana entitled “Role of Bihar's Agriculture Road map” in 25th Annual Conference & National Seminar of AGBJ Organized by the Department of Geography, Patna University, Patna on October 27-28, 2024 at the Department of Geography, Patna University, Patna.

v. Dr. Vidya Yadav Invited as a Resource Person to deliver talk on *"Livelihood and Occupational Diversification Strategies: A Pathway for Viksit Bharat@2047,"* scheduled on 4th - 5th December, 2024 at D.A.V. Post Graduate College, Siwan, Bihar.

vi. Dr. Vidya Yadav Attended Online Faculty Development Program (FDP) on "Smart Building Design: ECT for Net-Zero (Energy Efficiency, Control Systems & Thermal Comfort)” 2nd June – 11th June 2025", at NIT, Patna.

vii. Dr. Vidya Yadav Invited to chair the session (online) in the International Seminar on “Contemporary Geo-Environmental Issues in the Global South: Mapping, Resilience and Sustainable Solutions (CGEIGS-2025)” from July 11 to 12, 2025.

viii. Department of Geography, College of Commerce, Arts & Science, Patna, Observed & Organized talk on World Water Day by Dr. Syed Mohammad Saalim, on theme “Urgent Need for Preserving Glacier: Combating Climate” on 21st March, 2025.

ix. Department of Geography, College of Commerce, Arts & Science, Patna Celebrated and organized World Population Day on 11th July, 2025 and arranged a special talk by Dr. Tulika Singh, Associate Professor, Community health Medicine, IGIMS, Patna.

T.M. BHAGALPUR UNIVERSITY, BHAGALPUR

1. (a) **Joining of new faculty members from 01st October, 2024 to 15th September, 2025:**

Sl. No.	Name of Faculty Member	Place of Posting
1.	Dr. Pravin Kumar	University Dept of Geography, T.M.B.U.
2.	Dr. Gautam Pandey	University Dept of Geography, T.M.B.U.
3.	Dr. Mukul Kumar	University Dept of Geography, T.M.B.U.
4.	Dr. Karuna Raj	University Dept of Geography, T.M.B.U.
5.	Dr. Mukul Anand	T.N.B. College, Bhagalpur
6.	Dr. Kumar Vimal	T.N.B. College, Bhagalpur
7.	Dr. Priyanka Kumari	T.N.B. College, Bhagalpur
8.	Dr. Radha KUmari	T.N.B. College, Bhagalpur
9.	Dr. Manoj Pandey	Murarka College, Sultanganj
10.	Dr. Nawal Ram	Murarka College, Sultanganj
11.	Dr. Anita Kumari	Sabour College, Sabour

(b) **Appointment of Head from 01st October, 2024 to 15th September, 2025:**

Sl. No.	Name of Head	Posted at	Date of Joining	Remarks
1.	Dr. Prashant Kumar	University Dept of Geography, T.M.B.U.	12.08.2025	Dr. Aniruddh Kumar, former Head of the Department being appointed as Principal, at B.N. College, Bhagalpur by B.S.U.S.C.

(c) Dr. Aniruddh Kumar, former Head of the Department, University Department of Geography, T.M.B.U., being appointed as Principal at B.N. College, Bhagalpur by B.S.U.S.C.

2. **Seminar:**

A Multidisciplinary International Seminar was organised by University Department of Geography on the Topic "Adoption of Innovation and Sustainable Development: A way to Vishit Bharat @ 2047" on 11th and 12th of April 2025.

LALIT NARAYAN MITHILA UNIVERSITY

1. Departmental Events:

a) **GIS Day celebration** on 23 November 2024. A special lecture on the theme "Mapping Minds, Shaping the World" was organised. The main speaker of the event was "Dr SK Singh A". A total of fifty participants attended the event.

b) An invited lecture on the topic "**Environmental Ethics**" was organised on 27 November 2024. The main speaker of the event was Prof. GRP Singh, Former Dean (Social Sciences), LNMU. A total of seventy-two participants attended the event.

c) A national seminar on the occasion of **World Soil Day** was organised in collaboration with Prabhat Das Foundation on the theme "Mithila ki Bhoomi: Viksit Bharat kesanderbhmein". The main speaker of the event was Prof. KKL Das, Former Dean (Social Sciences), LNMU. A total of eighty-two participants attended the event.

d) A national seminar in collaboration with Talab Bachao Manch on the theme "**Mithila ki Bhoomi: Viksit Bharat ke sanderbh mein**". The main speakers of the event were Prof. Vidya Nath Jha (Botany), Prof. TT Jha (Geography), Dr Arvind Kr. Jha (History), and Sh. Narayan Ji Chaudhary (Talab Bachao Manch). A total of twenty participants attended the event.

e) A symposium was organised on "**Role of India Meteorological Department in Weather Forecasting**" on 15 January 2025. The main speaker of the event was Dr Manu Raj Sharma (Assistant Professor) and a member of the India Meteorological Society cum-coordinator of the Automatic Weather Station at LNMU. A total of eighty-six participants attended the event.

f) An invited lecture on the topic "**Modern Techniques of Weather Forecasting**" was organised on 4 February 2025. The main speaker of the event was LD Mahapatra, Scientist, IMD (Patna). A total of twenty-eight participants attended the event.

g) An invited lecture on the topic "**Indo-China Hydropower Projects in the Himalkayan Region: Issues and Challenges**" was organised on 19 February 2025. The main speaker of the event was Mr Gangesh Jha (Assistant Professor), Dept. of Pol. Science, CM College, Darbhanga. A total of thirty-six participants attended the event.

h) "**Earth Day**" was celebrated at the department on April 22, 2025. Main Speakers included Prof. Shahid Hassan, Dean (Social Sciences), and Prof TT Jha, Former Head (Geography). A total of sixty-two participants attended the event.

i) Organised **5 Day workshop** (24-28 April 2025) on "**Analysing Geographical and Statistical Data Using Python Programming Language and MS Excel**" at the University Department of Geography, LNMU. A total of 32 participants attended the workshop.

j) **Brainstorming session with scientists from IMD**, Patna and Kolkata. Dr Ashish Kumar, Head, Met-Centre, Patna, Ganesh Kr Das, Scientist-F, and Sachin Yadav, Scientist-C (IMD Kolkata) interacted with PhD students and teachers regarding insights about the climate of Bihar and new job opportunities for Geographers in climate sciences.

2. Conference/Seminars/Workshops Organised/Attended:

- **Dr. Anuranjan, Head of the Department**

  Contribution as chairman for a 5-day workshop on **"Analysing Geographical and Statistical Data Using Python Programming Language and MS-Excel"** at the University Department of Geography, LNMU, Darbhanga, April 24–28, 2025.

- **Dr Manu Raj Sharma, Assistant Professor**

a) Presented paper titled "Analysis of long-term Rainfall Trend, Variability, and Drought in the Baghmati-Adhwara River Basin, Bihar" in 19th International Geographical Conference on 'Geospatial Technology for Sustainable Development: A Way Forward for Viksit Bharat' organised by the Department of Geography, Central University of South Bihar, Gaya (Bihar), India scheduled on 22 to 24 February, 2025.

b) Participated in Eight-Day NEP 2020 Orientation & Sensitization Programme under Malaviya Mission Teacher Training Programme (MMTTP) of University Grants Commission (UGC), organised by Malaviya Mission Teacher Training Centre (MMTTC), Central University of South Bihar (CUSB), Gaya, in collaboration with Lalit Narayan Mithila University (LNMU), Darbhanga, 30th May to 7th June 2025

c) Contribution as convener for a 5-day workshop on "Analysing Geographical and Statistical Data Using Python Programming Language and MS-Excel" at the University Department of Geography, LNMU, Darbhanga, April 24–28, 2025.

d) Participated in a Training Program on "BHUVAN Overview" conducted by the National Remote Sensing Centre, ISRO, Hyderabad, 21-23 January 2025.

- **Dr Rashmi Shikha, Assistant Professor**

a) Presented paper titled "बागमती-कोसी दोआब में वर्षा की प्रवृति, वाष्पोत्सर्जन परिवर्तनशीलता और फसल उत्पादकता पर इसके प्रभाव का सांखियकीय विश्लेषण " in 19th International Geographical Conference on 'Geospatial Technology for Sustainable Development: A Way Forward for Viksit Bharat' organised by the Department of Geography, Central University of South Bihar, Gaya (Bihar), India scheduled on 22 to 24 February, 2025.

b) Contribution as **Organizing Secretary** in 5-day workshop on "Analysing Geographical and Statistical Data Using Python Programming Language and MS-Excel" at the University Department of Geography, LNMU, Darbhanga, April 24–28, 2025.

c) Contribution as rapporteur in XXV Annual Conference & National Seminar of AGBJ organised by Department of Geography, Patna University, Patna on 27th-28th October, 2024 to mark the occasion of Platinum Jubilee Year.

- **Dr Sunil Kumar Singh, Assistant Professor**

a) Participated in Eight-Day NEP 2020 Orientation & Sensitization Programme under Malaviya Mission Teacher Training Programme (MMTTP) of University Grants Commission (UGC), organised by Malaviya Mission Teacher Training Centre (MMTTC), Central University of South Bihar (CUSB), Gaya, in collaboration with Lalit Narayan Mithila University (LNMU), Darbhanga, 30th May to 7th June 2025

b) Contribution as resource person for a 5-day workshop on "Analysing Geographical and Statistical Data Using Python Programming Language and MS-Excel" at the University Department of Geography, LNMU, Darbhanga, April 24–28, 2025.

3. List of Publications:

- **Dr Anuranjan, Head of the Department**

i. Urban Flood Resilient: A study of flood 2019 in the city Patna, published in Annals of the Bhandarkar Oriental Research Institute, Vol C1 Issue 11,2024 with ISSN- 0378-1143, IF- 6.5, UGC care listed Group 1.

ii. Assessment of Urban Resilience: A study of Patna City, published in Annals of the Bhandarkar Oriental Research Institute, Vol C1 Issue 12, 2024 with ISSN- 0378-1143, IF- 6.5, UGC care listed Group 1.

iii. A community perception risk analysis of Japanese encephalitis in Gaya district, published in Humanities and Social studies journal, Vol 13 Issue-02No. 01 July- Dec, 2024 with ISSN-2319-829X, IF-7.28, UGC care listed Group-1.

iv. प्रमुख प्राकृतिक आपदाऐं एवं प्रबन्धन : बेगूसराय सदर प्रखण्ड के संदर्भ में published in Sampreshan, Vol. 17 Issue-1, 2024 with ISSN-2347-2979,IF-7.56, UGC care listed Group-1.

v. Mapping of Urban Growth and Urban Sprawl in the Patna urban Agglomeration area using Geo informatics techniques, published in Madhya Bharti – Humanities and Social Science (print)87, July-Dec 2024 with ISSN-0974-0066, UGC care listed Group-1.

vi. Ethical view of Socio- Ecological resilience and Quality of Life, published in International Journal of Applied Social Science, Vol.12(7&8)July & Aug, 2025with ISSN-2394-1405 (print), IF– 5.9.

vii. Mapping and monitoring of wet land farming in Madhubani district of Bihar, published in The Deccan Geographer, Vol. 62 No. 7 Dec,2024 with ISSN- 00117269, UGC care listed Group-1.

- **Dr Manu Raj Sharma, Assistant Professor**

i. From lightning flash to impact: mapping lightning hotspots, strike intensity, and casualty risks in the State of Bihar, India. Theoretical and Applied Climatology, 156(8), 431.

ii. Identification of Precipitation Trends, Evapotranspiration Variability, and its Impact on Grain Crop Productivity in Baghmati-Kosi Doab (2002-2023). Current Agriculture Research Journal. 13(1): 112-121. ISSN: 2347-4688. Online ISSN: 2321-9971. DOI: 10.12944/CARJ.13.1.12

iii. Century of Rainfall Dynamics and Drought in Bihar: Patterns, Trends, and Climatic Variability (1901-2021). Current World Environment 20 (1): ISSN:0973-4929, Online ISSN:2320-8031.

iv. Rainfall variability and trends in different agroclimatic zones of Bihar, India. Journal of Agrometeorlogy 27(1): 100-103. DOI: 10.54386/jam.v27i1.2686

v. From Agrarian fields to Suburban Centres: A case study of LULC in Kosi-Gandak Doab (2003-2023). Geographical Perspective 25: 73-91. ISSN: 0970-809X.

vi. Determinants and Spatial Patterns of Out-migration from Madhubani District: A case study of BISFI, India. Indian Journal of Spatial Science 15 (2):94–98. (ISSN-95542).

vii. Mapping long-term Transformation of Wetlands and Annual Rainfall Variability in Madhubani District (1975-2022). Current World Environment 19 (1): 251–268. ISSN:0973-4929, Online ISSN:2320-8031.

- **Dr Sunil Kumar Singh, Assistant Professor**

i. Gender Inequality in Begusarai District: A comprehensive Analysis, International Journal of Applied Social Science, 12(3&4):203-215. ISSN : 2394-1405.

B.R.A. BIHAR UNIVERSITY, MUZAFFARPUR

1. Joining

1. Prof. Pramod Kumar, Professor of Geography joined as Principal Nitishwar Mahavidyalaya, Muzaffarpur.
2. Prof. (Dr.) Rupa Kumari took charge of Head, University Department of Geography, B.R.A.B.U. Muzaffarpur on 01 February 2025.

2. Superannuation:

1. Prof. (Dr.) Jafar Imam, Superannuated from the University service on 31 January 2025.

3. Activities in the department:

i. A Seminar was organised in the Department, "Forest Fire: Causes, Consequences and Contemporary Challenges".

ii. A Seminar was organised in the Department, "Tourism In India: Opportunities and challenges". Keynote Speaker. Prof.(Dr.) Anoop Kumar Singh (PPU Patna), Patron. Prof. (Dr.) Rupa Kumari (HOD), Convenor. Dr. Shirin Hayat (Senior Assistant Professor), Co-convenor. Dr. Ida Ella Seema Kerketta (Associate Professor), Organising Secretaries. Dr. Rajeshwar Ray (Assistant Professor).

4. Faculty Achievements:

- **Prof. (Dr.) Rupa Kumari**

(i) Participated in XXV AGBJ "Climate change, Agricultural Practices and Food Security" Hosted by Department of Geography Patna University, Patna (Bihar).

- **Dr. Ida Ella Seema Kerketta**

(ii) She was elected as a Senate Member from Category A

(iii) Participated in XXV AGBJ "Climate change, Agricultural Practices and Food Security" Hosted by Department of Geography Patna University, Patna (Bihar)

(iv) Paper Publication, Dr. Ida Ella Seema Kerketta & Shikha Rani (MANAVIKI), "सीतामढी जिलें में भूमि उपयोग का बदलता स्वरूप एवं कृषि विकास पर प्रभाव: एक भौगोलिक अध्ययन" Vol. XVII, Reg.No. 600/2009-2010, ISSN 0975-7880.

(v) Paper Publication, Dr.Ida Ella Seema Kerketta " A Geographical Analysis of Litchi Cultivation, Spatial Distribution, and Production in Muzaffarpur District" Vol. 08 ISSN(online): 2643-9875, DOI:- 10.47191/IJMRA.

- **Dr. Shirin Hayat**

(i) She got promoted and became a Senior Assistant Professor.

(ii) Paper Publication, "Impact of Climate Change on Agriculture in Vaishali District" Vol.XVII, ISSN 0975-7880.

(iii) Paper Publication, Dr. Shirin Hayat, "Geographical Analysis of Litchi Cultivation, Spatial Distribution, And Production in Muzaffarpur District" Vol.08 ISSN (Online):- 2643-9875, DOI: 10.47191/IJMRA.

(iv) NEP 2020 Orientation and Sensitization Programme under Malaviya Mission Teacher Training Programme (MM-TTP) of University Grants Commission (UGC) organised by UGC- Malaviya Mission Teacher Training Centre, National Institute of Technology Warangal (15 Sep-23Sep 2025).

(v) Successfully completed the FDP Program on "Sustainable Energy Transition: Fuel Cell Technology Competing For Supremacy in Portable Electronics. Hosted by NIT Patna Electronics and ICT Academy, (17 Aug-27 Aug 2025).

5. Other Activities:

Geographical Tour: The University Department of Geography organized a two-day educational tour to Rajgir on August 5-6, 2025, for 40 students of P.G. Sem. IV, Session 2023-25, led by Professor Dr. Rupa Kumari and other faculty members. The tour included visits to historical sites like Pawapuri and Nalanda ruins on the first day, and natural sites like Nature Safari, Peace Pagoda, and Ghora Katora on the second day. The objective of the tour was to provide students with practical geographical experience.

JAI PRAKASH UNIVERSITY, CHAPRA

1. Joining

I. Prof. (Dr) Birendra Kumar, Professor of Geography Joined as Principal in Jamni Lal College, Hajipur, Vaishali (BRABU).

II. Prof. Sanjay Kumar, Professor of Geography, Jagdam College, Chapra joined as Principal S.K.R. College, birbigha, Sheikhpura (Munger University).

III. **New faculty members :**

(i) Alpna Jyoti
(ii) Bhupesh Kumar Mishra
(iii) Sushil Kumar
(iv) Pratyush Singh
(v) Neelambari Gupta
(vi) Visha Sharma
(vii) Bijay Das
(viii) Sushil Kumar Singh
(ix) Nishant Prakash
(x) Geeta Kumari
(xi) Nabitullah Mian
(xii) Praveen Kumar Bhaskar
(xiii) Nidhi Kumari
(xiv) Manoranjan Rajak
(xv) Nirbhay Kumar Ram
(xvi) Manju Kumari

2. Publications (book, article etc.) by faculty members:

- **Prof. Usha Singh**

i. Published an article on "Women workers in unorganised sector: A case study of domestic workers in Chapra town" IJRAR

ii. Published an article on Conservation of Groundwater Resources: Significance of JAL JEEVEN HARYALI MISSION in Kaimur Dist, Bihar.

- **Tapasya**

i. Published an article on वाराणसी नगर में जल गुणवत्ता सूचकांक के आधार पर पेयजल का मूल्यांकन .. कलासरोवर।

ii. Published an article on पेयजल आपूर्ति की स्थिति और समस्याए : वाराणसी का एक भौगेलिक विश्लेषण।

- **Neha Kumari Pandey**

i. Published an article on "Women workers in unorganised sector: A case study of domestic workers in Chapra town"

- **Dr Alpna Jyoti**

i. Published an article on Damming Impact on Riverine Geomorphology: A Case Study of the Kosi River Barrage in North Bihar.

ii. Published an article on Sustainable Development Targets and Goals of Viksit Bharat, 2047 in Saran Disrict of Bihar : A Geographical Analysis

iii. Published an article on Published a book "Quantitative Geomorphology (A case study of Masan Basin in North Western Bihar)"

3. Research Projects, Grants and Academic Collaborations :

i. Research Project (Collaborative) from ICSSR, New Delhi.

Title of Project : "An Exploratory Study on livelihood and Occupational Diversification Strategy of Rural Household in Bihar"

Project Coordinator : Dr. Ramanuj Kaushik Assistant Professor, Deptt. of Geography D. A. V Post Graduate College, Siwan

4. Conference, Seminar and Workshop organised/ participated:

- **Tapasya**

i. Participated in National Seminar on livelihood and occupational diversification Strategies.

ii. Participated in 25th Annual Conference and National Seminar AGBJ organised by Department of Geography, Patna University. Title "Climate Change and its consequences on Human Helth in Bihar.

iii. Participated in Two Days National on " Buddhist Circuit in Bihar: A Holistic Development" Organised by University Department of Geography, Magadh. University, Bodh Gaya Sponsored by ICSSR. Title "Tourism and Livelihood: The Changing Economic landscape of Bodhgaya."

iv. Participated in ICSSR (NRC) Sponsored National Seminar "SAMAGAM" on Sociological and Geographical Dimention of Global environment convergence Towards attaining sustainable Development Goals" Organised by Nehru Gram Bharti, Allahabad. Title जल गुणवत्ता सूचकांक के आधार पर वाराणसी शहर की पेयजल गुणवत्ता का आकलन।

- **Neha Kumari Pandey**

i. Participated in National Seminar on livelihood and occupational diversification Strategies.

ii. Participated in 19th DGSI International Geography Conference 2025 on " Geospatial Technology for sustainable development: A way forward to Vikshit Bharat"

iii. Participated in Two Days National on " Buddhist Circuit in Bihar: A Holistic Development" Organised by University Department of Geography, Magadh. University, Bodh Gaya Sponsored by ICSSR.

- **Dr Alpna jyoti**

i. Participated in 25th Annual Conference and National Seminar AGBJ organised by Department of Geography, Patna University.

ii. Participated in Role of Sustainable Urban Planning on Pathway to Viksit Bharat, 2047. Organized by XXVI Annual Conference & National Seminar Bihar And Jharkhand.

iii. Participated in a Workshop organised by Shikshan Prasarak Sansthan, Shri Okarnath Malpani Law Callege, Sanganer, Internal quality Assurance Cell.

- **Dr. Bhupesh Kumar Mishra**

i. Indian Knowledge System and Environmental Conservation: Path for ozone layer Protection Organized by Department of Geography, Maharaja Suhel DAV University Azamgah.

VEER KUNWAR SINGH UNIVERSITY, ARA

A. PG DEPARTMENT OF GEOGRAPHY

1. Joining :

i. Prof. N. K. Palit, Professor of Geography joined as Principal, M.M. Mahila College, Ara.

ii. Prof. Nazir Akhtar, Professor of Geography joined as Principal, Annugarh Memorial College, Gaya.

iii. **Joining of New Faculty Members:**

क्र.सं.	नाम	पोस्टिंग का स्थान
01.	शेर सिंह	Sri Tridandi Dev Govt. Degree College, Shahpur, Bhojpur
02.	अरुण कुमार	एच.डी. जैन कॉलेज, आरा।
03.	संदीप कुमार यादव	Sab Divisional Govt. Degree College, Nauhatta, Rohtas.
04.	अनिता सिंह	डी.के. कॉलेज, डुमरांव।
05.	Jitendra Kumar Jaiswal	एस.वी.पी. कॉलेज, भभुआ।
06.	अर्चना कुमारी	Sri Tridandi Dev Govt. Degree College, Shahpur, Bhojpur
07.	Divya Kumari	एस.बी. कॉलेज, आरा।
08.	रविशंकर तिवारी	एच.डी. जैन कॉलेज, आरा।
09.	Kislay Kalash	महाराजा कॉलेज, आरा।
10.	Kumar Purushotam Suman	एच.डी. जैन कॉलेज, आरा।
11.	तापसी कुमार	एस.एन. महाविद्यालय, शाहमल खैरादेव।
12.	मीरा कुमारी	एस.वी.पी. कॉलेज, भभुआ।
13.	Chandra Bhushan	डी.के. कॉलेज, डुमरांव।
14.	Mahtab Imam	एस.बी. कॉलेज, आरा।
15.	Punam Kumari	Sri Shankar College, Sasaram.
16.	आनंद कुमार	महाराजा कॉलेज, आरा।
17.	Munna Kumar Jyoti	एस.बी. कॉलेज, आरा।
18.	सुनीता कुमारी	Sri Shankar College, Sasaram.

2. Faculty Achievements:

- **Dr. Ratnesh Shukla**
- **Publication**

i. Chaturvedi, D.K. & Shukla, R. (2023). बिहार राज्य के जिला कैमूर में नगरीकरण का ग्रामीण क्षेत्रों से बाह्य प्रवास पर प्रभाव, Geography: ShodhSandarsh-XI, Vol. XXXVI, pp. 125-131.

ii. Chaturvedi, D.K. & Shukla, R. (2025). बिहार राज्य के जिला कैमूर में नगरीकरण का परम्परागत व्यवसायों पर प्रभाव, Shodh Drishti, Vol. 16, No.9, pp. 242-248.

iii. Kumar, A. & Shukla, R. (2025). ***Socio-Economic Status of Internal Migrant's: A Pilot Study of Behea Block of Bhojpur District (Bihar)*,** Shodh Drishti, Vol. 16, No. 8.1. pp. 137-142.

iv. Kumari, A & Shukla, R. (2025). बिहार में आयु-विशिष्ट कुल साक्षरता दर और कुल प्रजनन दर के मध्य अन्तर्सम्बन्धों का भौगोलिक विश्लेषण**,** Anukriti, Vol. 15, No. 5. pp. 169-175.

v. Kumar, M. & Shukla, R. (2025). जिला पूर्णिया में महिला साक्षरता दर में दशकीय परिवर्तन का स्थानिक विश्लेषण**,** Interdisciplinary Journal of Contemporary Research, Vol. 12, No. 6. pp. 163-169.

- **PAPERS PRESENTED IN NATIONAL SEMINARS & CONFERENCES**

i. **"Labour Migration and Environmental Sustainability: A Pilot Study of Slums of Ara City"** paper presented at National Seminar on Sociological and Geographical Dimensions of Global Environmental Convergence Towards Attaining Sustainable Developments Goals organized by Nehru Gram Bharati Deemed to be University, Prayagraj. on dated 1 to 2 October 2024.

ii. "जलवायु परिवर्तन विषयक जागरूकता में साक्षरता की भूमिका: बिहार के पूर्णिया नगर का प्रतीकात्मक अध्ययन" paper presented at National Seminar on Climate Change & Natural Disasters: Preparedness, Mitigation & Management Strategies Goals organized by Meerut College, Meerut on dated 23 to 24 November 2024.

iii. "बिहार राज्य में अनुसूचित जनजाति की साक्षरता और कृषि संलग्नता के मध्य अन्तर्सम्बन्धों का भौगोलिक अध्ययन" paper presented at National Seminar on आदिवासी भाषा, साहित्य, संस्कृति एवं इतिहास लेखन में नव विमर्श organized by Sardar Vallabhbhai Patel College, Bhabhua on dated 22 to 23 August 2025.

- **Dr. Ambarish Kumar Rai**
- **Publications (Oct 2024- Sept 2025)**

i. Rai, Rashmi &**Ambarish K. Rai,**(2025). Exploring the perceptions of vulnerability to victimization among women: A case study of Sambalpur city, India. *International Journal of Community Well-Being*, *8*(1), pp. 181-197, https://doi.org/10.1007/s42413-025-00242-7, **(Scopus Indexed) p-ISSN:** 2524-5295, **e-**ISSN: 2524-5309 **(Springer Nature)**

ii. Rai, Rashmi &**Ambarish K. Rai,**(2025). Navigating Fear: Women's Perceptions of Safety and Vulnerability in the Urban Landscape of Sambalpur, India. *Violence and Victims*, (In Press), DOI:10.1891/VV-2024-0194 **(Scopus Indexed) p-ISSN:** 0886-6708, **e-**ISSN: 1945-7073 **(Springer)**

- **Research Project**

i. **Project Coordinator** (2024-25) in **Indian Council for Social Science Research (ICSSR)** Collaborative Empirical Research Project of Rs. Ten Lakh on ***Jal Jeevan Mission*** entitled as ***"Socio-economic and Health Assessment of the Jal Jeevan Mission in Rural Bihar: An Empirical Study of Samastipur District"***in Veer Kunwar Singh University, Ara, Bihar Awarded by **ICSSR, New Delhi**.

- **Paper presented in National Seminars/ Conferences**

i. 46th Indian Geography Congress & National Conference of National Association of Geographers, India (NAGI) - 2024, on ***"Geospatial Technologies for Sustainable Energy Resources & SDGs: Policy Frame Works and Global Initiatives"*** at Department of Geography, University College of Science, Osmania University, Hyderabad, Telangana State, India, Paper presented entitled as *"Unpacking Women's Autonomy: Implications for Maternal and Child Health Care in India",* from December 27-29, 2024.

- **Participated in Workshops/Courses/ FDP**

i. Participated in the 21-day Winter School in **Geospatial Science & Technology** (Level 1: Standard Program)Supported by **National Geospatial Program, Department of Science & Technology (DST),** Government of India, New Delhi Organized by **Department of Geology, Central University of South Bihar,** Gaya, Bihar, India from 13th November 2024 to 3rd December 2024.

ii. Participated in **NEP Orientation & SensitizationProgramme** (MMC-039-2025-JAN-B-02863) under the aegis of Malaviya Mission Teacher Training Programme,Ministry of Education, Government of Indiaorganised byMMT Training Centre,**Indian Institute of Technology (Indian School of Mines), Dhanbad** from 20th January 2025 to 31st January 2025.

B. MAHARAJA COLLEGE, ARA

i. 26/10/2024 - Episode 7 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Ratnesh Shukla, P.G. Dept. of Geography, V.K.S.U., Patna on 'Methods of Primary Data Collection and its Uses in Geographical Studies and Research Work'.

ii. 27-28/10/2024 – Prof. Sanjay Kumar (HOD) attended the XXV Annual Conference and National Seminar of AGBJ on 27.10.2024 - 28.10.2024 at Patna University, Patna. Also Chair the technical session no – 20.

iii. 05/11/2024- Prof. Sanjay Kumar, invited and attended the State Level Role Play Competition 2024 as a Judge, held at Sri Krishna Science Centre, Patna, organised by SCERT, Patna.

iv. 16/11/2024- Prof Sanjay Kumar invited and attended the One Day Training Workshop of Bio Diversity Board as an Expert, organised by Bhojpur Van Pramandal, Ara at Hotel Park View Clarks Inn.

v. 26/11/2024 - Episode 8 of Prof. S.K. Sinha Memorial Online Lecture Series in Collaboration with Aerobott Pvt. Ltd. And ASIM Navigation India Pvt. Ltd.by Dr. Pranay Kumar, Ms. Aparna Mishra, Dr. Saurabh Srivastava and Mr Sumit Katyal., Mumbai on 'Advancing Careers in Geography: Insights into Drone Technology and AI".

vi. 18/12/2024 - Episode 9 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Saroj Kr. Singh, (HOD), P.G. Dept. of Geography, V.B.U., Hazaribagh, Jharkhand on 'Impact of Climate Change on Migration: Issues and Challenges'.

vii. 21/01/2025 - Episode 10 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. HEENA (M.A., MPhil., Ph.D., Dept. of Geography, Delhi School of Economics, DU), on 'Groundwater Pollution And Its Impact On Human Health'.

viii. 02/02/2025 – Field Visit to Suhia Bhangar Wetland, Shahpur Block on World Wetland Day.

ix. 23/02/2025 – Dr. Dweepika S. Singh participated in the DGSI XIX International Conference on Geospatial Technology for Sustainable Development at Central University of South Bihar, Gaya and presented her paper ""Mobility and Empowerment: A Spatio-Temporal Analysis of Women's Freedom of Movement in Bihar"

x. 24/02/2025 - Episode 11 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Md. Akhtar Ali, Asst. Professor, Osmania University, Hyderabad on 'Role of NGO's in Disaster Management'.

xi. 18-24/3/2025 - P.G. Dept. of Geography, Maharaja College, Ara conducted a Primary Survey on the Socio-Economic Conditions of the Musahar Community in Village Chaurai, Block -Udwantnagar, District- Bhojpur, Bihar.

xii. 28/03/2025 - Episode 12 of Prof. S.K. Sinha Memorial Online Lecture Series by Prof. Dilip Kumar, Shaheed Bhagat Singh Evening College, University of Delhi, New Delhi on 'Geo-Spatial Information Technology and Sustainable Rural Development'.

xiii. 12/04/2025- Prof. Sanjay Kumar delivered a special lecture on "How to conduct Socio-Economic Survey of Micro Region" at P.G.Department of Geography, Vinoba Bhawe University, Hazaribagh, Jharkhand.

xiv. 28/04/2025 - Episode 13 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Uday Kumar, Assistant Regional Director, IGNOU, Regional Centre- Port Blair, Andaman and Nicobar Islands on 'Open and Distance Learning (ODL) as an Alternative Mode of Higher Education in India.

xv. 22/05/2025 - Episode 14 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Ravi Sharma, HOD- Sustainability Management Dept. Symbiosis Institute of International Business (SIIB); Symbiosis International (Deemed University), Pune on 'Ecosystem Services: Importance and impact of biodiversity loss.

xvi. 05/06/2025 – Cleanliness and Plantation drive in collaboration with Forest Dept., Bhojpur Van Pramandal, at Suhia Bhangar wetland area on World Environment Day.

xvii. 21/06/2025 - Episode 15 of Prof. S.K. Sinha Memorial Online Lecture Series by Ms. Babli, Yoga and Fitness Expert and Trainer, New Delhi on 'Globalization of Yoga: India's Contribution towards One Health" on World Yoga Day.

xviii. 11/07/2025 - Episode 16 of Prof. S.K. Sinha Memorial Online Lecture Series by Dr. Abhishek Kumar, Technical Advisor – SRHR, Population Council, New Delhi on "Well-Being and Health Situation of Adolescents and Youth in Bihar" on the eve of 'World Population Day.

xix. 13/07/2025 - Prof. Sanjay Kumar invited at SCERT, Patna for the Vetting of educational videos. Prof. Sanjay Kumar Explained the method of vetting and importance of vetting of educational videos to the TRE passed school teachers at SCERT Studio.

xx. Rupa Kumari, student of the department has won Gold Medal in South Asia Wrestling Competition at Kathmandu, Nepal.

xxi. 18/7/2025 - District level 'Van Mahotsav' organized by Department of Environment, Forest, and Climate Change, Govt. of Bihar along with P.G. Dept. of Geography, Maharaja College, Ara on 18th August.

20-21/9/2025- Dr. Dweepika S. Singh presents her paper on the topic " Cyber-Geographies of Everyday Life: A Comparative Study of Spatial Shifts in Work, Education, and Social Interaction in Bhojpur, Bihar (2010–2025)" at the International Conference on Literature, Society and the Global Media , 20 - 21 September, 2025. The Paper is selected in the "Best Presentation" Award" category

ARYABHATTA KNOWLEDGE UNIVERSITY, PATNA

THE SCHOOL OF GEOGRAPHICAL STUDIES

1. Joining

I. In addition to a regular Assistant Professor, Dr. Manish Parashar, three Guest faculties have been appointed at the School of Geographical Studies-
   i. Dr. Angad Yadav,
   ii. Dr. Dayanand Kumar
   iii. Dr. Rabindra Paswan

2. Activities:

i. A Tree planting Campaign was organised at the University on 25.01.2025, where the Assistant Professor, Ph.D. Scholars and M.A. /M.Sc. Students of Centre of Excellence actively took part at it.

ii. Matribhasha Diwas was organised on 21.02.2025 at the School of Geographical Studies. The day highlighted the importance of preserving languages, fostering cultural identity, and ensuring inclusive education. Experts emphasized on Multilingual education. They stressed, "it not only enhances learning outcomes but also allow students to grasp concepts in their native language, improving comprehension and retention. Additionally, policies supporting linguistic diversity contribute to equity in education, ensuring that students from diverse backgrounds receive quality learning experiences".

iii. International Women's Day (IWD) was celebrated on March 8 at the School of Geographical Studies, Aryabhatta Knowledge University, Patna, to honour women's achievements and advocate for gender equality. The title of the theme was "आधी आबादी की पूरी हिस्सेदारी". Students and co-workers highlighted the women's achievements in various realms, self-dependency and confidence.

iv. World population Day was celebrated on 11th July 2025 to raise awareness about global population issues. The School of Geographical Studies, School of Mass Communication and National Service Scheme jointly grasped this opportunity to organize a one-day seminar on the theme "Population: A Boon or a Burden". The event aimed to create awareness among students and scholars about population dynamics and sustainable development. The seminar commenced at 12:30 PM with the address of Dr. Manish Parashar, an eminent Geographer and Head of the School of Geographical Studies and the address of Dr. Manisha Prakash, a well-known name in the field of journalism and Head of the school of Journalism and Mass communication.

v. The School of Geographical Studies organized a Poster Competition and Vox Pop on the occasion of World Ozone Day, celebrated every year on 16th September to raise awareness about the importance of the ozone layer and the need to protect it. Students from M.A. Geography programmes actively participated in the poster competition, preparing innovative and informative posters on themes such as Ozone Layer Depletion, Sustainable Planet, Save Earth, and Climate Action.

3. Publications:

i. Dr. Manish Parashar, Assistant Professor, School of Geographical Studies published his Research Paper in INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS, titled – "Understanding air Pollution in Bihar: A District-Level Analysis of causes, Effects, and Mitigation Strategies".

ii. Sarita Kumari, Ph.D. Research Scholar published her Research Paper, "असंगठित क्षेत्र में घरेलु महिला कामगारों की आर्थिक स्थिति का विश्लेषणात्मक अध्ययन", was published online in www.universitypublication.in, INSIGHT: AN INTERNATIONAL MULTILINGUAL JOURNAL FOR ARTS AND HUMANITIES.

iii. Sarita Kumari, Ph.D. Research Scholar published her research paper in AGPE THE ROYAL GONDWANA RESEARCH JOURNAL OF HISTORY, SCIENCE, ECONOMIC, POLITICAL AND SOCIAL SCIENCE, titled – "प्रवास और घरेलु महिला श्रमिक पर इसका प्रभाव".

iv. Ph.D. Research Scholar, Kritika Priyadarshni published her Research Paper under the supervision of Dr. Manish Parashar, Assistant Professor, School of Geographical Studies, Aryabhatta Knowledge University, Patan in INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS. The title of her Research Paper was – "The Rural Urban Fringe: A Key Area for Future Urban Planning and Settlement Dynamics"

v. Ph.D. Research Scholar, Mr. Vishwanath Prasad published his Research Paper entitled "Towards Sustainable Urban Futures: A Comprehensive Study on Solid Waste Management in India" under the supervision of Dr. Manish Parashar, Assistant Professor, School of Geographical Studies, Aryabhatta Knowledge University, Patan in INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS.

Ph.D. Research Scholar, Mr. Saurav Kumar published his research paper entitled "Navigating Hurdles in the Development of Smart Cities: Insights from India" under the supervision of Dr. Manish Parashar, Assistant Professor, School of Geographical Studies in INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS.

VINOBA BHAVE UNIVERSITY, HAZARIBAG

Chancellor's Lecture Series (May 2025)

The Department of Geography organized a series of five lectures delivered by eminent Geographers across the country under the Chancellor's Lecture Series programme. This initiative significantly enriched the teaching–learning process of the department, benefiting both faculty and students.

Sl No.	Date	Topic	Resource Person
1.	10/05/2025	Sustainable Utilization of Resources of Bihar and Jharkhand @Viksit Bhart 2047	Dr. A. R. Siddiqui, Former Head, Dept. of Geography, Allahabad University, Allahabad.
2.	14/05/2025	Population Growth and its Impact upon Environment	Dr. Anil Kr. Singh, Ex. HOD, Dept. of Geography, BBMKU, Dhanbad.
3.	17/05/2025	Some Aspects of Geographical Research	Dr. Ram Kr. Tiwari, Ex. HOD, Dept. of Geography, Ranchi University, Ranchi.
4.	21/05/2025	Relevancy of Instrumental Survey in Geographical Studies	Prof. N. K. Mahto, Ex – Coordinator, Amanat, Remote Sensing and GIS, Dept. of Geography, DSPMU, Ranchi.
5.	28/05/2025	Geology and Geomorphology of Jharkhand	Dr. Jitendra Shukla, H.O.D, Dept. of Geography, Ranchi University, Ranchi.

Foundation Day Lecture (10 May 2015)

The Department of Geography organized the Foundation Day Lecture of the Association of Geographers Bihar and Jharkhand on 10th May 2025. On this occasion, during the Executive Meeting of AGBJ, the focal theme for the 26th AGBJ Conference, "Sustainable Utilization ofResources of Bihar and Jharkhand @Viksit Bharat 2047" was finalized. In addition, a special lecture was delivered by Prof. A.R. Siddiqui, Professor, Allahabad University, Allahabad as a Keynote Speaker.

Invited Lectures

In addition to the Chancellor's series, the department also hosted several invited lectures by distinguished geographers from different parts of the country. These academic interactions provided valuable insights and broadened the horizons of the students.

Study Tour (24/01/2025-28/01/2025)

Sl No.	Date	Topic	Resource Person
1.	05/10/2024	Food Security in India: Constraints and Possibility	Dr. Veerendra Kumar, Professor, Dept. of Geography, Magadh University, Bodh Gaya.
2.	16/10/2024	Resource Potentials for Tourism in Bihar and Jharkhand	Dr. Manoj Kr. Sinha, Professor and Head, Dept. of Geography, Patna College, Patna.
3.	09/09/2025	Spatial Data Representation by Choropleth Method	Dr. Ravi Shekhar, Professor, CSRD, JNU, New Delhi.

Educational tour is an important part of geographical studies, the department organized a Five Days Study Tour to Bhubaneswar, Puri and Konark. The Study tour provided direct observation about geographical, cultural and ecological aspects of the region to students.

KOLHAN UNIVERSITY, CHAIBASA, JHARKHAND

1. Articles published :

i. Dr. Sunita Kumari published an article on "Tribal Migration for Employment and Skill Development Program: A Case Study West Singhbhum District, Chaibasa inn edited Book, Tribal Development and Identity Kanak Publication, Delhi, 2025.

ii. Status of Tribal Migration for Employment in Jharkhand journal of Impact and Policy Research Review vol3, issue2 July-December 2024 Publication By Mr. Kanchan Kachhap

iii. The Education Gap: A Barrier to Tribal Development in India Chaibasa edited Book, Tribal Development and Identity Kanak Publication, Delhi, 2025.

2. Seminar:

i. Workshop Organised by University Department of Geography Kolhan University, Chaibasa on Qualitative research Methods in December 2024.

3. Research Project :

- **Project Done by Dr. Sunita Kumari**

i. ICSSR New Delhi, Major Project titled Tribal Migration for Employment from West Singhbhum District (Kolhan Region) of Jharkhand' .

ii. The Research Project sanctioned by the Dr. Ramdayal Munda Tribal Welfare Research Institute, Ranchi Project Title: - Titled "A Socioeconomic and Cultural Analysis of Changing Inter and Intra-household Relations in Tribal Communities of Jharkhand".

Ph. D. Degree Awarded

(From October, 2024 to September, 2025)

Patna University, Patna

Sl. No.	Name of Scholar	Topic of Thesis	Name of Supervisor
1.	Anna Emiliya Fernandes	"Quality of Life of South Indian Migrants in Patna Municipal Corporation Area".	Dr. Sister Maria Rashmi A.C.

Patliputra University, Patna

Sl no.	Name of the scholar	Title of the thesis	Name of the supervisor
1.	Vishal	Integrated Area Development of Bojpur District, A Geographical Study	Dr Vinita Prasad

Tilkamanjhi Bhagalpur University, Bhagalpur

Sl. No.	Name of Research Scholar	Title of Thesis	Name of Supervisor
1.	Sudhakar Kumar	बीड़ी निर्माण उद्योग में सलंग्न श्रमिकों की समाजिक–आर्थिक–सांस्कृतिक दशाः जगदीशपुर अंचल, भागलपुर के संदर्भ में भौगोलिक विश्लेषण	Prof. Sharat Chandra Former Head, University Deptt. of Geog. T.M. Bhagalpur University.
2.	Mukhlesur Rahman	A Geographical Study of the Problems and Prospects of Wheat Farming in Murshidabad District,West Bengal(India)	Prof. Sharat Chandra Former Head, University Deptt. of Geog. T.M. Bhagalpur University.
3.	Jilaruddin Ahmad	Agricultural Production in Birbhum District of W.B.: A Gegraphical Analysis	Prof. S. K. Jha Former Head, University Deptt. of Geog. T.M. Bhagalpur University.
4.	Mr. Sujan Kumar	गोड्डा जिला के सौरिया पहाड़िया की सामाजिक आर्थिक स्थिति का भौगोलिक अध्ययन।	Prof. S. K. Jha Former Head, University Deptt. of Geog. T.M. Bhagalpur University.
5.	Mr. Ayush Bharti	Urban Problems and Prospective Planning: A Case Study of Bhagalpur City, Bihar	Dr. Aniruddh Kumar Former Head, University Deptt. of Geog. T.M. Bhagalpur University.

L.N. Mithila University, Darbhanga

S.N.	Name of Scholar	Topic of Thesis	Name of Supervisor
1	Prity Priya	Bio-diversity vulnerability & management of wetlands : A case study of Kusheshwarsthan in Darbhanga, Bihar	Dr. Anuranjan
2	Alpana Kumari	Urban Growth & its Impact on Public utility Services in Patna Municipal Corporation area.	Dr. Anuranjan
3	Deepak Dipankar	Hazard Mapping & Assessment of Urban Resilience : A Study of Patna City, Bihar.	Dr. Anuranjan
4	Navin Kumar	भूमि उपयोग एवं कृषि पर जनसंख्या संरचना का प्रभाव गढ़पूरा प्रखण्ड बेगूसराय के संदर्भ में।	Dr. VN Jha
5	Manoj Kumar	Impact of Natural Disasters on livelihood pattern of Madhubani District	Dr. KK Mishra
6	Mrityunjay Kumar	दरभंगा सदर प्रखण्ड में अनुसूचित जातियों की स्थिति की समीक्षा : एक भौगोलिक अध्ययन।	Dr. RK Jha

Jai Prakash University, Chapra

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1	Soni Kumari	माध्यमिक एवं +2 विद्यालयों में भूगोल शिक्षण का शिक्षण का प्रतिरूप : सारण जनपद का प्रतिक अध्ययन	Prof. Usha Singh
2	Mr. Subodh Kumar	सिवान जिला में जनसंख्या के भौतिक एवं आर्थिक परिवर्तन का स्थानिक कालिक विश्लेषण।	Prof. Murari Singh
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Veer Kunwar Singh University, Ara

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Vinoba Bhave University, Hazaribag

Sl No.	Name of the Ph.d Scholar	Name of The Topic	Name of The Supervisor
1.	Dr. Sanjay Ravidas	Spatio-temporal Variation of Socio-economic Condition of Schedule Casts in Hazaribag District during 1951–2011: A Geographical Analysis	Dr. O.P. Mahto
2.	Dr. Dinanath Thakur	हजारीबाग सामुदायिक विकास प्रखण्ड के भूमि उपयोग प्रतिअप में स्थानिक एवं कालिक परिर्वतन का कारण (1991–2001): एक भौगोलिक	Dr. P.K. Singh

Kolhan University, Chaibasa, Jharkhand

Sl. No.	Name of Scholar	Title of Thesis	Name of Supervisor
1	Dr. Sharda Sharan Pandey	Human Resource and Environmental Pollution in East - Singhbhum District -A Geographical Study	Dr. Md. Ryaz

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6.	T. M. Bhagalpur Univ., Bhagalpur	Prof. V. N. P. Sinha	Prof. V. N. P. Sinha	Prof. R. B. Mandal	Prof. R. B. P. Singh	Prof. D. P. Singh	18-19 Oct., 2004	5th Annual Conference
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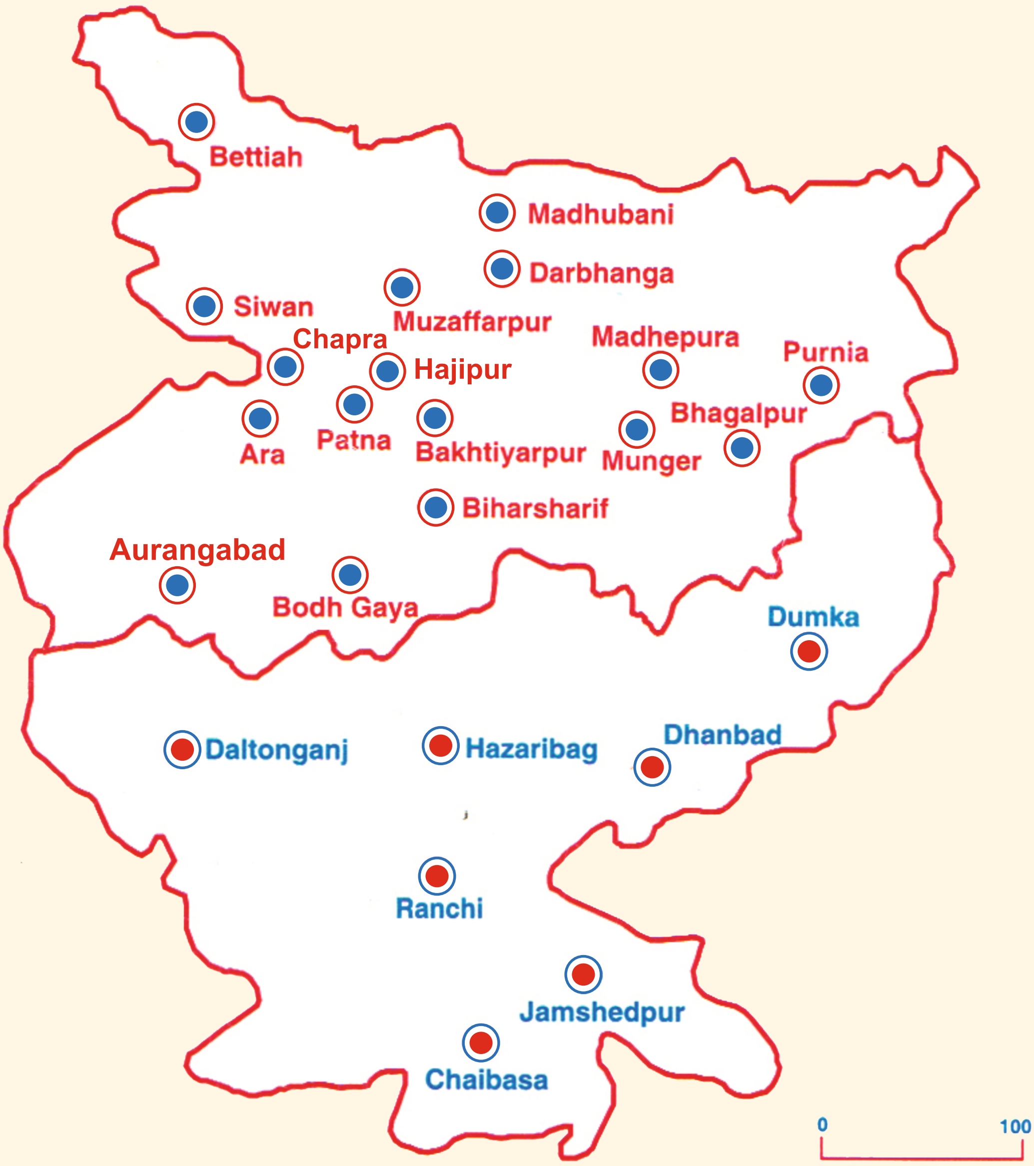

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