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ACCELERATING WATER HYACINTH IN ANASAGAR LAKE OF AJMER CITY: AN ENVIRONMENTAL CONCERN

Monika Kannan, Rishi Saxena and Kumar Gaurav

Abstract

Water hyacinth (WH) is infamous for its significant environmental harm and the financial strain it imposes for control measures. Nonetheless, there are considerable opportunities for utilization, particularly among rural populations. The plant thrives in areas where it has been introduced due to elevated temperatures, eutrophic conditions, and other environmental influences. For the past six months increasing water hyacinth in Anasagar lake has been a reason for severe concern, as its expansion hampers aquatic life and also impacts the ecological environment. The deployment of machines and manpower over the last few months have failed to put a check on their accelerating expansion in Ana Sagar Lake in Ajmer from being smothered under a carpet of water hyacinth. Water testing to analyse the major reasons responsible for growth and expansion of water hyacinth is undertaken. Sample have been collected from ten random places across the lake over a period of five months (January-May 2024. Water testing methods-IS: 3025 (Part-11):2022, IS 3025 (Part-9) : 2023, IS: 3025 (Part- 32):1988, IS: 3025 (Part-10):2023, IS 3025 (Part- Sec–1): 2022. Trend of accelerating spread of water hyacinth has been monitored through Google Earth Pro. Meteorology data has been acquired from Indian Meteorological Department, New Delhi for the last five months. ArcMap has been used to extract the observed values and expansion rates of water hyacinth in the lake. The observed values are corelated with the area extracted from Arcmap and relationships have been established. Levels of Chloride, Nitrates, Dissolved oxygen and pH have been majorly taken consideration. Studies indicate that hyacinth plant grows in a wide range of temperatures between 13° to 40 °C but optimally grows from 25° to 30°C.

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Introduction

Water hyacinth, scientifically known as Eichornia crassipes and locally referred to as Meteka, is acknowledged as one of the most prolific plants globally, producing over 200 tons of dry matter per hectare annually under typical circumstances. In environments with high sewage concentrations, it can yield as much as 657 tons of dry matter per hectare. Numerous investigations have been conducted on water hyacinth and its expansion, such as K.M. Jagadeesh and C.S. Lakshminarayana (1971) have also contributed a brief review on water hyacinth control and utilization. O.P. Gupta and P.S. Lamba (1976) reviewed the use of aquatic plants for fodder, compost, protein carotene, fish food, pulp and paper, culture for yeast and antibiotics, medicinal ingredients, and for pollution abatement. The authors urge that interdisciplinary research is needed for the appropriate commercial exploitation of aquatic plants. Such an approach alone could ensure adequate control of important aquatic weeds in the tropics and subtropics. J.L. Fox and H.S. Prentice (1975) have reviewed methods of harvesting aquatic plants. C.E. Boyd (1972) has prepared a comprehensive bibliography on aquatic weed use which he has classified into seven groups: chemical composition and nutritive value; nutrient removal; productivity and standing crop; ecology and life history; identification; aquatic plant nutrition and physiology; nutrient relationships in aquatic environments.

Study Region

Lake Anasagar is a threatened water body of Ajmer city of Rajasthan. Ajmer originally known as Ajayameru is an administrative center in the state of Rajasthan, which is located at distance of about 355 km in the southwest part of New Delhi, the Capital of India. In the eastern section of the district, the terrain is predominantly flat, occasionally interrupted by mild undulations. Conversely, the western areas, stretching from the northwest to the southwest, are crossed by the Aravalli Range. Within this region, several valleys consist of sandy deserts, forming a part of India's Thar Desert, occasionally punctuated by cultivated oases. Amidst these, there are fertile patches, including the plain where the town of Ajmer is situated. This valley features the Anasagar Lake, an artificial reservoir, safeguarded by the imposing walls of the Nagpathar range, also known as the Serpent rock, serving as a barrier against encroaching sand. As per historical evidence, Anasagar Lake is a man-made lake which was constructed by King Annaraj in year 1135-1150. The lake area is being encroached on for housing which has reduced water spread. Total area of Anasagar Lake: 2 sq km. The catchment area of lake is. 70.55sq.km and its circumference are

12.88sq.km. The land use and land cover surrounding Anasagar Lake are shaped by both natural elements and socio-economic influences. Land cover encompasses the physical and biological features covering the land surface, including water bodies, vegetation, bare soil, and man-made structures. Details of Anasagar lake are as below: The catchment area of lake is - 70.55 Sq km (7055 Hectares), Area of lake at full tank level is - 2.96 Sq Km (296 Hectares), Capacity to hold water is - 247.64 mcft, Full tank level is - 13 feet Status of Anasagar as a Wetland As per the provision of rule 3 of Wetlands (Conservation and Management) Rules, 2017 Anasagar Lake is not a Wetland. Total length of circumference of Anasagar lake at Full Tank Level (FTL) is approximately 10363 m out of which pathway in approximately 4000 m already exist and balance length is taken up under Ajmer Smart City Mission.

Objectives

(1) To analyze the major factors responsible for increasing water hyacinth in Anasagar lake of Ajmer city.
(2) To evaluate the trend of accelerating spread of water hyacinth in Anasagar lake since January 2024.
(3) To examine the impact of expansion of water hyacinth in Anasagar lake on its aquatic ecosystem.
(4) To discuss and suggest the need to conserve and protect the Anasagar lake.

Materials and Methods

Sample have been collected from ten random places across the lake over a period of five months (January-May 2024. Water testing methods-IS: 3025 (Part-11):2022, IS 3025 (Part-9) : 2023, IS: 3025 (Part- 32):1988, IS: 3025 (Part-10):2023, IS 3025 (Part- Sec-1): 2022. The increasing proliferation of water hyacinth has been tracked using Google Earth Pro, while meteorological data from the Indian Meteorological Department, New Delhi, over the past five months has been obtained. ArcMap has been employed to extract and analyze the observed values and expansion rates of water hyacinth within the lake. Utilizing satellite imagery and field observations, distinct land use/land cover categories have been delineated within the catchment area of Anasagar Lake, including significant land use changes observed over time. The area has been classified into five primary categories through land use/land cover analysis. These include the water spread area, comprising both permanent water bodies and seasonal swampy areas, as well as the built-up land area, housing small communities adjacent to the lake. Furthermore, agricultural land has been identified as a predominant land use, reflecting the primary activity within the catchment area.

Water samples from Anasagar lake were collected for 5 months from January 2024-May 2024 for water quality testing. Chemical testing is undertaken to check the pH vale, Chlorides, Nitrates, phosphorus, dissolved oxygen, turbidity and salinity.

Result And Discussion

Factors Responsible for Increasing Water Hyacinth

The water hyacinth (Eichhornia crassipes (Mart) Solms) poses a significant challenge as an aquatic weed, having proliferated in lakes, ponds, and rivers not only within our country but across the entire tropical world. Consequently, there has been considerable attention directed towards its environmental impact, given its robust growth disrupting human activities and raising substantial concerns. Its widespread presence in freshwater lakes and riverbeds is adversely affecting fishing, boating, and diminishing water levels, while also impeding water utilization and other related endeavors. Acknowledging the severity of the situation, measures have been undertaken to combat the water hyacinth menace through the implementation of biocontrol methods. Due to its prolific growth and dense foliage, water hyacinth presents a myriad of challenges (Photo-1). Its abundance of leaves and dense vegetation, coupled with numerous rootlets arranged in a tertiary manner, obstructs water flow in irrigation channels and hinders hydroelectric power generation. Additionally, it interferes with navigation, impedes the natural flow of water, and displaces various aquatic grasses that serve as fodder for cattle. Furthermore, water hyacinth suppresses the growth of phytoplankton, disrupting the delicate ecological balance of aquatic ecosystems. The major factors which determine the growth and expansion of water hyacinth are, namely, Total phosphorus (TP) and total nitrogen (TN) content of the lake water, Water surface temperature (T) of the lake water, Amount of Salinity in the lake water, pH of the water and, Water depth of the lake. Wilson et al. [27] reported that under constant temperature and nutrient levels, the projected growth rate of water hyacinth is 0.1 kg/m^2. However, in nutrient-rich or eutrophic conditions, this rate can escalate to 10 kg/m^2. With an optimal average temperature of 30°C, it takes approximately 50 days for the plant to achieve the 10 kg/m^2 rate. Consequently, water hyacinth invasions are primarily observed in equatorial regions with warm temperatures and eutrophic lakes, where rivers and wetlands are commonly and severely affected. Zhang et al. [26] highlighted that the invasive (Table-1).

Photo - 1

Table-1: Climatic Conditions in Ajmer City for the Last Five Months

Month	Temperature		Humidity	Pressure	Water Hyacinth
January	High	26°C (31 Jan, 14:30)	100% (11 Jan, 08:30)	1025 mbar (11 Jan, 08:30)	1.6 sq km
	Low	6°C (11 Jan, 07:30)	23% (11 Jan, 16:00)	1013 mbar (16 Jan, 15:00)	
	Average	15 °C	73%	1019 mbar	
February	High	31 °C (19 Feb, 14:30)	100% (4 Feb, 22:00)	1025 mbar (4 Feb, 22:00)	2.0 sq km
	Low	9°C (9 Feb, 06:30)	17% (17 Feb, 17:00)	1008 mbar (19 Feb, 16:00)	
	Average	20 °C	51%	1018 mbar	
March	High	38°C (27 Mar, 14:00)	94% (1 Mar, 20:00)	1022 mbar (1 Mar, 20:00)	2.3 sq km
	Low	12°C (4 Mar, 07:00)	9% (17 Mar, 17:00)	1008 mbar (22 Mar, 15:30)	
	Average	25 °C	38%	1015 mbar	
April	High	39°C (18 Apr, 16:00)	65% (1 Apr, 05:30)	1016 mbar (1 Apr, 05:30)	1.7 sq km
	Low	22°C (2 Apr, 05:30)	6% (30 Apr, 15:30)	1004 mbar (19 Apr, 16:30)	
	Average	31°C	28%	1010 mbar	
May	High	36°C (2 May, 16:00)	32% (1 May, 06:00)	1010 mbar (1 May, 06:00)	2.3 sq km
	Low	23°C (2 May, 06:00)	8% (1 May, 14:00)	1005 mbar (1 May, 00:00)	
	Average	29°C	18%	1007 mbar	

spread of water hyacinth is characterized by genetic uniformity due to its prolific clonal reproduction, predominantly through vegetative propagations.

Trend of Accelerating Spread of Water Hyacinth

Eexpansion of Water Hyacinth and Related Variables

The growth and expansion of water hyacinth is dependent on various variables. In Anasagar lake there have persistent trials by the local administration and the concerned departments to clear the water hyacinth and conserve the lake. Studies indicate that the most favorable conditions for the optimum growth of water hyacinth are nutrient-rich water, temperature ranges from 28°C to 30°C, pH value between 6.5 and 8.5, salinity < 2% (Fig. 2).

(a) Temperature: Seasonal change was observed in the lake temperature. Studies indicate that hyacinth plant grows in a wide range of temperatures between 13° to 40 °C but optimally grows from 25° to 30°C. Thus, tropical as well as subtropical regions in the world are favorable for the growth of water hyacinths. The average temperatures recorded were 15°C (January) and 29°C May (Table-1) in Ajmer. The growth and expansion have been at an accelerating rate since January in the lake.

(b) pH: Maximum and minimum values of 8.6 and 7.8 were recorded in the Anasagar lake water. With reference to table1, the minimum growth of water hyacinth was observed in April, 2024 when the pH vale was observed minimum in the last 5 months.

(c) Dissolved Oxygen (DO): The permissible limit of DO in absence of Alternate Source as per IS 10500:2012 is 6.5–8 mg/l. January-6mg/1, February-4mg/1, March-6mg/1, April-4mg/1 & May-3mg/l. Researches indicate that expansive growth of water hyacinth leads to decrease in DO levels. The data indicates a strong relationship between the observed DO levels and hyacinth growth in the Anasagar lake (Photo-2).

(d) Nitrates: The permissible limit of Nitrates in absence of Alternate Source as per IS 10500:2012 is maximum 45 mg/l. As per the studies, Nitrate concentrations are low during the period of high-water hyacinth infestation in any region. In Anasagar Lake the of nitrates range of 10-16mg/1 was observed for the last 5 months, with least in the month of April, 2024. However, as per the data acquired by satellite imagery indicates that the area under hyacinth was less in April in comparison to other months. This could be possible due to the consistent efforts of the local government initiatives to check it. It was observed that several dedicated teams have been working on the lake to remove the hyacinth and nearly 300 trucks were found carrying the extracted water hyacinth from the lake on a daily basis.


Satellite Imagery of Anasagar Lake, 2014
Sewage Treatment Plant
Anasagar Lake
Satellite Imagery of Anasagar Lake, 2024
Sewage Treatment Plant
Anasagar Lake

Photo - 2

(e) Chloride: Unlike chloride concentration, salinity is a measure of the total salt concentration, comprised mostly of Na+ and Cl– ions in saltwater and brackish water. Chloride is essential in helping fish maintain their osmotic balance. Chloride content of water is dependent on its salinity level among other factors. The permissible limit of Chloride in absence of Alternate Source as per IS 10500:2012 is maximum 1000 mg/l.

Studies indicate that sulphate and chloride are significantly lower in the water hyacinth-infested areas which could be due to the absorption of the nutrients by water hyacinth. The observed values of Chloride in Anasagar lake range between 451 mg/l (February) to 503 mg/l (May), where the area under water hyacinth was 2.0 sq km & 2.3 sq kms respectively.

Negative Impacts of Weed

(a) While water hyacinths have some positive impact; the weeds can be expensive nuisance in many ways:

(b) They can clog dam outflows and disrupt hydro-electric power generation intakes and irrigation canals.

(c) Interfere with water supply systems by blocking pipes pumping water from the dam, impair navigation, i.e., the mat formed by the weeds cannot allow the smooth passage of canoes and engine powered boats,

(d) Curtail recreation activities such as swimming, boat cruise and other attractions.

(e) Damage fisheries by making it difficult for some fishing methods such as fishing nets to be spread on water.

(f) Weeds also deplete aquatic biodiversity where some fish species either die or migrate while free breeding is also inhibited.

(g) The weed also changes water chemistry by reducing its levels of oxygen leading to suffocation and eventual death of other living organisms including fish. This phenomenon could have led to the disappearance of the Kafue bream.

(h) The weeds become breeding places for mosquitoes and other creatures like snakes, frogs and snails-hence, diseases like malaria, schistosomiasis, encephalitis, filariasis and cholera.

(i) Excessive wastage of water through transpiration. The rates of loss can be up to 13 times that from a free water surface.

(j) Weeds can also reduce the speed and quantity of water flowing in the dam thereby increasing the possibilities of flooding.

Positive Effects of Weed

On the positive side water hyacinths can be used as water purifiers because of their capability to absorb high levels of poisonous chemicals such as sulphides and other heavy metals. In some countries the weed is used to build wetlands or as animal feeds and manure for farmlands. Water hyacinth plants have a tremendous growth and reproductive rate and the free-floating mats cause substantial problems. Millions of dollars are annually allocated in the United States for the management of water hyacinth, which has been widely distributed due to the allure of its large, purple to violet flowers. Although water hyacinth hasn't been spotted in the wild in Washington, it is marketed as an ornamental plant in nurseries. Despite assumptions that it cannot endure Washington's winters, its presence as an ornamental increases the risk of escape and establishment in the wild. While water hyacinth may not survive freezing conditions in Washington, it thrives in other states with established populations, potentially adapting to the relatively warm winters of western Washington. The formation of thick mats of water hyacinth leads to a depletion of dissolved oxygen crucial for fish, birds, and other aquatic life. Additionally, these mats create breeding grounds for mosquitoes and other disease-carrying insects by stagnating water in ditches and shallow areas. Water hyacinth also carries pathogens that can infect various crops, and its presence introduces unpleasant odors, coloring matter, and suspended particulate matter into water bodies. Moreover, the rapid production of organic matter by water hyacinth results in the accumulation of dead organic matter in water, while floating mats serve as ideal habitats for rats, exacerbating rodent infestations in farmland and crop fields. Water hyacinth forms dense mats of floating vegetation and reproduces through seeds and daughter plants that sprout from rhizomes, forming dense plant beds. In one study, two plants generated 1,200 daughter plants within four months. Individual plants detach from the mat and can be dispersed by wind and water currents. A single plant can produce as many as 5,000 seeds, which are consumed and dispersed by waterfowl. Seedlings commonly grow on mud banks exposed by low water levels.

Conclusion

The ecology of water hyacinth (WH), the socioeconomic consequences of its invasion, and its diverse applications are assessed, emphasizing revenue generation and cost-saving alternatives. By empowering local communities with opportunities and showcasing potential economic benefits, there's a chance to encourage pro-environmental behavioral shifts in WH management. This approach not only enhances local livelihoods but also builds resilience within communities to address both environmental challenges and economic downturns caused by WH invasions. With reference to Anasagar Lake of Ajmer, the Solid Waste Treatment Plant (STP) situated at the periphery of lake cannot be ignored. Studies indicate that, municipal solid waste leachate (liquid materials that drain from stockpiled material or land) should be considered a source of nutrients. The number of studies based on nutrient recovery from leachate tends to escalate nutrients content. There can be a relationship between the release of nutrients from the STP in Anasagar lake which might have led to the increase of water hyacinth in the region. However, there are no substantial evidences to prove the same, hence it needs further introspection and thorough examination. Anasagar lake is a centre for attraction for not just the local Ajmer residents and the tourists visiting the city, but also acts as a pivotal centre for biodiversity concentration. Thousands of birds, fishes, and other aquatic lives are dependent on the lake for livelihood. Water hyacinth can completely cover lakes and wetlands, outcompeting native aquatic species, reducing oxygen levels for fish, and creating ideal habitat for disease-carrying mosquitoes. It is difficult to get rid of water hyacinth because they can vegetatively multiply at a remarkable rate and cover all the water bodies in a shorter amount of time. The broad and wide leaves of the water hyacinth can extend up to one meter above the surface of the water. Its removal will help to conserve water and rejuvenate the environment and Sustainable livelihood & Inclusive Growth will be regained in the region. Various methods such as mechanical, chemical, and biological approaches are employed to manage water hyacinth growth, each with its own set of advantages and disadvantages. However, alterations in dissolved oxygen levels and trophic structure caused by cutting plants can exacerbate eutrophication and lead to the proliferation of water hyacinth blooms. Chemical control, while less labor-intensive and costly on a large scale compared to mechanical methods, can have far-reaching ecological impacts as herbicides may unintentionally harm non-target algae and macrophytes. Biological control presents an alternative to mechanical and chemical methods. It requires less labor and equipment and has the potential to become a self-sustaining solution.

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ASSESSING THE ROLE, STATUS AND CHALLENGES OF THE PRADHAN MANTRI UJJWALA YOJANA ON SOCIO-ECONOMIC EMPOWERMENT OF WOMEN IN NUH DISTRICT, MEWAT REGION, HARYANA

Aamir Suhel, Anjan Sen and Ashutosh Mishra

Abstracts

In India, women have historically been central to the management of households, especially in the realm of cooking. Nonetheless, the dependence on biomass fuels for cooking has presented considerable health, economic, and social challenges. The Pradhan Mantri Ujjwala Yojana (PMUY), launched in 2016, is a flagship scheme of the Government of India aimed at providing clean cooking fuel to women from Below Poverty Line (BPL) households across the country. This is the world's largest social program to provide free LPG (liquified petroleum gas) cylinders for the needy. Based on this background, this descriptive research paper analyses this research article explores the multifaceted role of PMUY in promoting the socio-economic empowerment of women in Nuh, evaluates its effects on their well-being and means of subsistence, and examines the challenges that persist in achieving its objectives. The findings of the study revealed that, in Nuh, Haryana, where traditional cooking practices predominantly involve the use of biomass fuels, the Pradhan Mantri Ujjwala Yojana holds significant potential for transforming the socio-economic landscape for women in Nuh, Haryana. By providing access to clean cooking fuel, PMUY not only improves health outcomes but also enhances women's economic participation and social empowerment. Nonetheless, obstacles persist that require focused attention and collaboration among governmental bodies, non-profit organizations, and community participants. By addressing these challenges, PMUY has the potential to foster a more just and thriving future for women in Nuh.

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Introduction

Today, clean fuels play a significant role in the overall development of humans and is at the heart of many critical challenges and opportunities the world faces today, from poverty eradication to combating climate change (Kumar & Kadam 2023: Hammeed et al. 2016; D'Sa & Murthy 2004). Clean fuels burn completely in the presence of sufficient oxygen and produce far less smoke & other toxic gases such as oxides of Sulphur which cause serious health ailments (Sahu et al. 2024). It has been widely reported that around 38% of the world's population still relies on traditional biomass for cooking (Gould & Urpelainen 2018). This figure highlights a significant global issue, as many people, particularly in low-income and rural areas, use biomass fuels such as wood, crop residues, animal dung, and charcoal for cooking and heating (Andadari et al. 2014; Sharma & Singh 2019; Tripathi, 2019). According to the Census of India (Chandramouli and Registrar General, 2011), 63% of households in rural India depend on firewood, and 23% use crop residue and cow dung as cooking fuels. LPG penetration constitutes only 11% of rural households while for electricity it is less than even 0.1% for rural households and 0.15% for urban households (Aggarwal et al. 2018). The Sustainable Development Goal-7 seeks to guarantee access to affordable, reliable, sustainable, and modern energy for everyone by 2030. In India, the Pradhan Mantri Ujjwala Yojana (PMUY) serves as a significant initiative that aligns with this objective. Initiated in 2016, PMUY seeks to deliver clean cooking fuel (LPG) to economically disadvantaged households, especially rural women who have historically depended on harmful biomass for their cooking needs (Mall & Rani, 2020). Its success contributes not only to energy security but also to better health, gender equality, and environmental sustainability, demonstrating the multifaceted impact of clean energy access on sustainable development (Barua, 2019; Swain et al.2019; Kaviya & Sumati, 2024). Nuh district (formerly known as Mewat) in Haryana is one of the most socio-economically backward regions in India and is located on the foothills of Aravalli's range in the southern part of Haryana. Despite its proximity to the National Capital Region (NCR), traditional cooking practices in Nuh continue to rely significantly on biomass fuels, and the adoption rate of PMUY in this region is one of the lowest in the country. This paper will examine the effects of the Pradhan Mantri Ujjwala Yojana (PMUY) on the socio-economic empowerment of women, investigate the barriers contributing to the low uptake of the scheme in the district, and build a decision support system for its efficient execution and management.

Study Region

Nuh district, formerly known as Mewat, is located in the state of Haryana, India, and is one of the most socio-economically disadvantaged regions in the country. The area was officially formed on April 4, 2005, known as 'Satyamev Puram', by incorporating regions from the Gurgaon district and the Hathin sub-division of the Faridabad district. In 2008, this region was given a new name, 'Mewat', and ultimately renamed Nuh in 2016. Nuh district is situated between 26°14’ - 30°02’ north latitude and 76°04’-78°11’ east longitude. This area is characterized by its hilly terrain and encompasses parts of the ancient Matsya-desh and Surasena, this district showed serious flaws in the areas of health and nutrition, education, water and agriculture, basic infrastructure, financial inclusion, and skill development, despite its proximity to the National Capital Region (NCR) and Haryana's thriving industrial and financial center. According to the Census 2011, district Nuh's population was 1,089,263 of which male and female were 571,162 and 518,101 respectively. Nuh is predominantly inhabited by the Meo Muslim community, who are historically agrarian and have experienced social and economic marginalization. The district has one of the lowest literacy rates in Haryana (54.08%), with a significant gender gap in educational attainment. Sex Ratio in District Nuh stood at 907 per 1000 males compared to the 2001 Census figure of 899. The healthcare infrastructure is underdeveloped, and the region has high poverty and unemployment rates, with much of the population dependent on low-yield agriculture. The district’s infrastructure is inadequate, with poor road connectivity, irregular electricity supply, and limited access to financial and public services. These factors contribute to its ongoing socio-economic challenges, making Nuh one of the most backward districts in the country, requiring focused developmental efforts for upliftment.

Objectives

(1) To Investigate the Role of PMUY in Enhancing Women's Socio-economic Empowerment and Independence.

(2) To analyze the cause of low penetration of the PMUY among the needy in the Nuh district.

Database and Methodology

This study is grounded in empirical evidence, utilizing a descriptive approach for the collection of data. This study fundamentally relies on both primary and secondary data to gather more comprehensive insights into the process. The respondents were identified through a purposive sampling which means data was only collected from beneficiaries of LPG connections under the 'PMUY'. The primary data were collected in May 2024 from 113 respondents using a structured questionnaire at different locations homes, streets, agricultural farms, and Anganwadi centers. The questionnaires were divided into two sections. The first section addresses socio-economic factors including age, sex, family size, caste, religion, educational qualifications, and annual income. The second section evaluates the impact of the PMUJ scheme, its effects, and the challenges encountered by beneficiaries of LPG connections. The convenience sampling method was employed to identify the respondents in this study, with samples collected exclusively from individuals who have benefited from the PMUJ Scheme. Before sample collection, a pilot study was conducted, and based on the feedback from relevant stakeholders, the final version of the questionnaire was distributed and collected using a direct survey method. The true identities of the interviewees were substituted with respondent numbers to maintain their confidentiality. The collected quantitative data has been analyzed employing several statistical techniques, such as averages, percentages, regression analysis, and one-way ANOVA, all executed within the Statistical Package for Social Sciences (SPSS). Conclusions were derived from this analysis. This study exhibits some limitations, including constraints related to time and resources as well as potential sampling and non-sampling errors.

Result and Discussion

This study employed both quantitative and qualitative techniques to achieve the stated objectives. The information concerning the demographic profile of the respondents, including aspects such as location, income, age, and education, has been detailed in Table 1 for the study. Table-1 shows that most of the respondents live in rural areas (81.40%), with only 18.58% in urban areas. This rural dominance suggests that the challenges and perspectives on energy access (like LPG through PMUY) are largely influenced by rural conditions such as infrastructure, income, and education. Meo Muslims (80.50%) form the majority of the respondents, with Hindus (19.50%) making up a smaller proportion. The largest age group is 26-35 years (26%), followed closely by 36-45 years (24%) and 46-55 years (20%). A significant portion (19%) earns less than ₹5,000, indicating widespread poverty in the region. Only 12% have an income above ₹30,000 (Fig. 1 and Table-1). This income distribution highlights that affordability is likely a major issue for accessing and refilling LPG cylinders, particularly for low-income households. Although LPG cylinders were distributed to the economically disadvantaged at significantly discounted costs under the 'PM Ujjwala yojana,' majority of respondents expressed that the consistent price

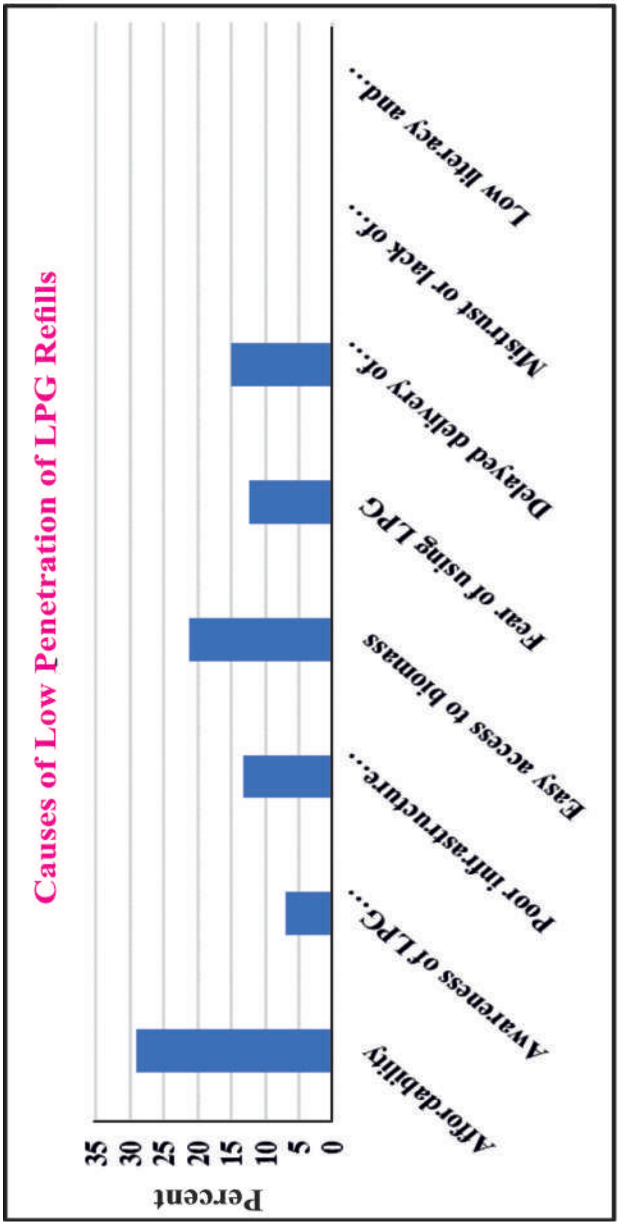
Causes of Low Penetration of LPG Refills
Percent
35
30
25
20
15
10
5
0
Affordability
Awareness of LPG...
Poor infrastructure...
Easy access to biomass
Fear of using LPG
Delayed delivery of...
Mistrust or lack of...
Low literacy and...

Fig. 1

increases, made it unaffordable. Despite getting the subsidy, the LPG cylinders are still expensive (Fig. 1). That means subsidies are limited which might not cover increasing costs, putting additional financial pressure on weaker sections. Numerous households in economically disadvantaged areas experience fluctuating incomes, making it challenging to budget for recurring expenses like gas refills. 33% of respondents refilled their LPG cylinders 4-6 times in a year, followed by 29% who refilled 1-3 times.

Table-1: Demographic Profile of the Respondents

Variables	Category	Frequency	Percentage
Religion	Muslims	91	80.5
	Hindu	22	19.5
Location	Rural	92	81.4
	Urban	21	18.6
	Total	113	100
Age (in Years)	18-25	19	16.8
	26-35	29	25.7
	36-45	27	23.9
	46-55	23	20.4
	55 Above	15	13.3
	Total	113	100
Household Income (Monthly)	Below ₹5,000	22	19.5
	₹5,000 - ₹10,000	32	28.3
	₹10,000 - ₹20,000	25	22.1
	₹20,000 - ₹30,000	21	18.6
	Above ₹30,000	13	11.5
	Total	113	100
Education Level	No formal education	53	46.9
	Primary	27	23.9
	Secondary	16	14.2
	Higher Secondary	11	9.7
	Graduate and above	6	5.3
	Total	113	100

Contd...

Source of awareness about PMUY	Media (TV, Radio, Newspapers)	52	46
	Government officials	16	14.2
	Friends/Family	37	32.7
	Community meetings	7	6.2
	Others (please specify)	1	< 1
	Total	113	100
Refilled Rate of LPG Cylinder in One Year PMUY Beneficiaries	0 Times	28	24.8
	1-3 Times	33	29.2
	4-6 Times	37	32.7
	Above 6	15	13.3
	Total	113	100
Barriers to LPG Refills	Affordability	33	29
	Awareness of LPG refill	8	7.1
	Poor infrastructure and limited access	15	13.3
	Easy access to biomass	24	21.2
	Fear of using LPG	14	12.4
	Delayed delivery of LPG	17	15
	Mistrust or lack of engagement with government programs	1	< 1
	Low literacy and educational attainment	1	< 1
	Total	113	100

Source: Fieldwork

However, 25% did not refill their cylinders even once. This indicates that while many beneficiaries are using the cylinders regularly, a significant proportion is unable to maintain consistent use, likely due to barriers such as cost or access. This is followed by other significant barrier such as Fear of accidents or safety concerns (H15) and Cultural preferences and traditional cooking practices of the study area (H9) (Behera, & Mallick, 2023). The participants discussed the safety aspects of LPG cylinders. Panic ensued among some beneficiaries, accompanied by numerous misconceptions, including the belief that LPG cylinders are entirely unsafe and that leaks or improper storage could pose significant dangers. A small number of participants indicated that adequate ventilation is necessary for LPG cylinders. Prevalent cultural preferences and traditional cooking practices of the study area is also responsible for low adoption rate of PMUY. In rural regions the majority of individuals depend on various alternative fuels based on their availability, including firewood, coal, dung cake, crop residue, and more. Despite the fact that these conventional energy sources generate significant indoor pollution that can be harmful to health. These fuels are relatively more economical than LPG cylinders. Transporting LPG cylinders to remote areas is often hindered by inadequate infrastructure, such as poorly maintained roads and transport facilities. In many rural or isolated regions, there is a shortage of distributors, making it difficult to refill. Delivering LPG cylinders to far-flung areas can be prohibitive, leading suppliers to prioritize more accessible locations, resulting in intermittent availability. Nearly 47% of respondents have no formal education, and only 5% are graduates or have a higher qualification. The low education levels likely contribute to low awareness about the benefits of PMUY and its proper usage, as well as barriers related to engagement with government programs. Limited formal education, particularly among women, could also influence their decision-making autonomy regarding the use of clean cooking fuels like LPG. 46% of respondents became aware of PMUY through media (TV, radio, newspapers), while 33% learned about it through friends and family.

This suggests that media plays a crucial role in disseminating information, but community and social networks are also vital in raising awareness. The majority of the social media speculation incited anxiety among the beneficiaries. Therefore, it is essential for the government to recognise the importance of informing and educating the public regarding LPG cylinders. Affordability (29%) is the most commonly reported barrier, followed by easy access to biomass (22%), and delayed delivery of LPG (18%). Awareness (15%) and poor infrastructure (13%) are also notable challenges. Linear regression analysis was utilized to ascertain the influence of the PMUY program as a predictor (independent) factor on women's socio-economic empowerment and independence (dependent variable) of an individual (Selvam et al. 2022, Yadav, 2020), as detailed in Table-2. The linear regression model indicated a calculated R-squared of .983 and an adjusted R-squared of .980. The model accounted for 98.3% of the total sum of squares as explained by the computed model. The standard error in our suggested model is 0.100, significantly exceeding the standard deviation (0.074) of the dependent variables. Therefore, the application of the proposed model is suitable. The findings of ANOVA analysis in Table 2 demonstrates significance at the 5% level, with a p-value of 0.000 and F statistic of 4.445, so validating the suitability of the suggested model as commendable overall. The R-squared value of 0.983 indicates that the suggested model accounts for about 98% of the total variation regarding the impact of the Ujjwala Yojana plan and its effects on socio-economic empowerment among women in the research area.

Table-2: Descriptive statistics of Regression and One Way ANOVA Analysis

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.990a	.983	.980	.100	1.390

a Predictors: (Constant). Impact of PMUY scheme on socio-economic Empowerment of Women

ANOVA					
Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	62.623	13	4.444	4.445	.001b
Residential	.986	100	1.000		
Total	63.609	113			

b. Dependent Variable: Impact of PMUY scheme on socio-economic Empowerment of Women

To achieve the objectives of the study, two broad sets of null hypotheses were formulated and tested, consisting of eight and seven sub-hypotheses, respectively. First null hypothesis (H_0) of the study is: The Ujjwala scheme does not have a positive effect on the socio-economic empowerment of women in the study area. To investigate the correlation between various dimensions of PMUY and socio-economic factors associated with women's empowerment, under this eight sub-hypotheses (H1, H2, H3, H4, H5, H6, H7 and H8) were formulated as given in Table 3. Additionally, seven other hypotheses are designed to pinpoint the elements that contribute to the limited adoption of PMUY in the Nuh district. Second null hypothesis of the study contains (H_0): Low penetration of the Pradhan Mantri Ujjwala Yojana (PMUY) in the study region is not influenced by a range of socio-economic, infrastructural, and cultural factors. In order to meet the study's objectives, two broad sets of null hypotheses were formulated and examined, comprising eight and seven sub-hypotheses, respectively. The first null hypothesis (H_0) of the study posits that the Pradhan Mantri Ujjwala Yojana (PMUY) does not positively influence the socio-economic empowerment of women within the study area.

The second null hypothesis of this study posits that the limited adoption of the Pradhan Mantri Ujjwala Yojana (PMUY) in the region under investigation is unaffected by various cultural, socioeconomic, and infrastructure-related variables. To explore the relationship between different aspects of PMUY and the socio-economic factors associated with women's empowerment has led to the formulation of eight sub-hypotheses (H1, H2, H3, H4, H5, H6, H7, and H8). Furthermore, to determine the statistically significant factors that influence the limited adoption of PMUY in the Nuh district, seven additional sub-hypotheses have been established and examined by employing the multiple linear regression (MLR) analysis, as outlined in Table-3. Multiple regression is the statistical procedure to predict the values of a response (dependent) variable from a collection of predictor (independent) variable values.

Table-3: Standardized Regression Coefficient Statistics

Model	Unstandardized Coefficients		Standardized Coefficients	t value	Sig (ρ)
Variables	Beta (β)	Std. Error	Beta (β)		
1.Empowerment* (Constant)	-.113	0.042	-	.614	.583
H1: Demographic Factors Influencing Awareness and # Adoption of PMUY.	.436	.072	0.322	2.627	.024
H2: The adoption of LPG through PMUY leads to improved # Health outcomes.	.508	.172	0.407	4.213	.041
H3: Access to LPG under PMUY increases women's participation in # Income Generation.	.474	.195	0.283	2.879	.072
H4: The use of LPG provided under PMUY reduces the time spent on cooking and fuel collection, improving women's overall quality of life (# Work-Life Balance).	.513	.247	0.451	3.464	.050

Contd...

H5: PMUY beneficiaries are more likely to pursue # Educational or Skill development opportunities due to the time saved from using LPG.	.346	.062	0.154	.073	.25
H6: The implementation of PMUY increases women's autonomy and # Decision Making Power within the household.	.859	.138	0.357	-1.754	.033
H7: PMUY reduces # Gender-based Inequalities by easing the burden of household work on women.	-.859	.103	0.059	-1.594	.37
H8: Households with women beneficiaries of PMUY experience a reduction in household poverty levels due # Financial Independence.	-.508	.162	0.304	3.168	.051
H9: # Cultural preferences and traditional cooking practices of the study area lead to resistance toward adopting LPG connections under PMUY.	.314	.056	.245	2.137	.000
H10: # Poor infrastructure and limited access to LPG distribution networks, hindering the successful implementation of PMUY.	.130	.036	.046	1.162	.728
H11: # Low literacy and educational attainment among women, contributing to lower adoption rates.	.147	.042	.038	1.953	.584

Contd...

H12: Under the PMUY scheme rural LPG users do not go for frequent refills due to # Insufficient funds.	.425	.062	.417	3.043	.012
H13: # Insufficient awareness and information dissemination about the benefits of LPG and PMUY contribute to the low penetration of the scheme.	.008	.083	.004	.074	.631
H14: # Mistrust or lack of engagement with government programs due to religious or community-based concerns in the Nuh district limits the uptake of PMUY.	.001	.069	.002	.016	.763
H15: # Fear of accidents or safety concerns related to using LPG may lead to reluctance in adopting PMUY.	.389	.725	.312	4.047	.031
* Dependent Variable: Women Empowerment (Constant)					
# Independent Variables (predictors)					

Source: Authors

It is inferred from table 3 that Adoption to PMUY (β=0.32, t=2.627, p=0.04), Health (β= 0.32, t= 4.213, p=0.04), Work Life Balance (β=0.451, t=3.464, p=.050), Decision Making Power (β=0.357, t=-1.754, p=0.033), Financial Independence (β=0.304, t=3.168, p=0.051) have statistically significant positive effects on socio-economic empowerment. Since many variables have significant positive coefficients, we reject the null hypothesis (H1, H2, H4, H6 and H8) and conclude that the Ujjwala scheme has a positive effect on the socio-economic empowerment of women. Whereas, the other three variables like Income Generation ($\beta = 0.283$, $t = 2.879$, $p = .072$), Educational and Skill development ($\beta = 0.154$, $t = .073$, $\rho = 0.25$), and Gender based Inequalities ($\beta = 0.059$, $t = -1.594$, $\rho = 0.62$) are not statistically significant, as their p-values are greater than 0.05. Hence, the null hypothesis is accepted (H3, H5 and H7) at 5% level of significance. The real application of Standardized Coefficients is to rank predictors (or independent or explanatory variables) as these eliminate the units of measurement of independent and dependent variables. We can rank independent variables with an absolute value of standardized coefficients. The most important variable will have the maximum absolute value of the standardized regression coefficient (Selvam et al. 2022). Thus, based on standardized regression coefficient statistics, our study revealed that, PMUY exerts the most substantial positive influence in the areas of improved quality of life and work-life balance (H4), ultimately leading to significant boosts in women's socioeconomic empowerment in the research region. As H4 has the highest value of Standardized Coefficients ($\beta = .451$). This finding is supported by the fact that the use of LPG provided under PMUY reduces the time spent on cooking and fuel collection. Additional variables that demonstrate a positive and statistically significant impact on women's socio-economic empowerment as a result of PMUY include health (H2), decision-making authority (H6), and financial independence (H8), listed in order of their diminishing significance and descending β values. In the analysis of the seven variables contributing to the low adoption of PMUY, in the study are (H9, H10, H11, H12, H13, H14 and H15), Cultural preferences and traditional cooking practices of the study area ($\beta = .245$, $t = 2.137$, $\rho < 0.05$), Unaffordability caused by insufficient funds ($\beta = .417$, $t = 3.043$, $\rho < 0.05$) and Fear of accidents or safety concerns ($\beta = .312$, $t = 4.047$, $\rho < 0.05$) emerged as statistically significant, as their ρ -values are lower than 0.05 (Table. 3). However, the primary obstacle among all others is Unaffordability due to insufficient funds (H9), evidenced by its highest Standardised Coefficients value ($\beta = .417$). Therefore, it can be concluded that our second null hypothesis is also rejected, indicating that the low penetration of the Pradhan Mantri Ujjwala Yojana (PMUY) in the study region is attributed to a range of socio-economic, infrastructural, and cultural factors.

Conclusion

The study following a comprehensive regression analysis, concludes that the PMUY is an excellent initiative for enhancing the socio-economic empowerment of women in the study area. It is revolutionizing their way of life by shifting from cow dung cake and wood to LPG. This initiative supports rural women by safeguarding their health and contributing to national efforts to mitigate air pollution resulting from biomass usage. It is also concluded from this study that the rural, low-income population of the region, characterized by low education levels, faces significant challenges regarding LPG affordability, infrastructure, and cultural barriers, which hinder the sustained use of LPG under PMUY. The media serves as an essential mode for raising awareness; however, there is a need for enhanced government outreach to address mistrust and foster greater engagement with PMUY. Although numerous households replenish LPG cylinders several times annually, the cost and the convenient access to biomass hinder some from regularly utilizing clean cooking fuel. Thus, this study reflects the socio-economic complexities that hinder the effective implementation of the Pradhan Mantri Ujjwala Yojana (PMUY) in the Nuh district. To overcome barriers and empower women to adopt clean energy solutions, it is essential to focus on affordability, enhance infrastructure, and strengthen government outreach.

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POPULATION AND DWELLING DENSITY GROWTH, TREND AND SOCIO-ENVIRONMENTAL IMPACT OF RAIGANJ SUBDIVISION, UTTAR DINAJPUR, WEST BENGAL

Bapi Sarkar

Abstract

Population and dwelling Growth have experienced significant changes in recent decades, driven by urbanization and economic opportunities. This trend has increased pressure on local infrastructure, housing, and resources. The rapid expansion has socio-environmental implications, such as depletion of natural resources, strain on public services, and environmental degradation due to unplanned population and household distribution. Additionally, socioeconomic disparities have intensified, with vulnerable communities facing inadequate access to basic amenities, as seen in Raiganj Sub-Division. The study focuses on population growth and dwelling expansion, primarily due to urbanization, migration, and increased economic activities. The objectives are to analyze the Growth of population density and dwelling density, as well as trends and socio-environmental impact of population and dwelling density growth (1981-2011). The analysis utilized tables, graphs, and choropleth maps and time series prediction to depict Growth and rates using Excel, SPSS, and ArcGIS. Raiganj Sub-Division had significant population and household expansion from 1981 to 2011. Population density rose by 105.90%, with significant increases of 34.57% from 1991 to 2001 and 19.89% from 2001 to 2011. Household density significantly increased 151.84% from 1981 to 2011, indicative of rapid population and heightened demand for housing and infrastructure. Sustainable population planning and environmental management are essential to balance Growth with the preservation of ecological and social well-being in the region.

Introduction

The rise and trend of population and dwelling density are interconnected elements that profoundly affect society and the environment (McGuirk & Argent, 2011). As populations expand, housing needs escalate, resulting in heightened residential density (Opoko et al., 2014). This trend is marked by an increasing individual residing in restricted environments, frequently within multi-family dwellings, apartment complexes, or informal settlements. Global population and housing density are rising, especially in developing nations such as India, where urbanization intensifies. Accelerated population expansion and economic advancement are compromising the environment (Shanker Singh & Narayan Pandey, 2012). It illustrates the intricate relationships among population dynamics, resource depletion, and environmental degradation (Daily & Ehrlich, 1994). The swift proliferation of urban areas and industry, the escalation of agricultural practices, and the degradation of natural ecosystems are propelling environmental decline at a concerning rate (Adekomaya & Majozi, 2022). A salient issue highlighted is that India, characterized by its vast population and constrained geographical area, encounters considerable difficulties in managing its natural resources (P., 2001). The demands of an expanding population result in deforestation, water shortages, air and water pollution, and soil depletion (Singer, 1985). Poverty exacerbates the issue, compelling individuals to unsustainably abuse the environment for essential resources such as food, fuel, and shelter (Hollander, 2003). With ongoing population expansion, resource scarcity will increasingly pose a significant challenge, necessitating sustainable development to mitigate future environmental degradation (Dincer & Rosen, 1999). The problem is to balance growth and resource utilization, ensuring that future generations inherit an unspoiled environment and adequate resources (Roy, 2021). The Uttar Dinajpur district, located in northern West Bengal, India, has significantly increased in recent decades. The Uttar Dinajpur district in West Bengal is partitioned into two subdivisions: Raiganj and Islampur (Government of West Bengal, 2009). The Raiganj subdivision comprises the blocks of Raiganj, Hemtabad, Kaliaganj, and Itahar, whilst the Islampur subdivision encompasses Chopra, Islampur, Goalpokhar I, Goalpokhar II, and Karandighi.

These blocks function as administrative divisions tasked with administration and development in rural regions, each encompassing many gramme panchayats that oversee local resources and infrastructure. The Census of India reveals this demographic trend. In 2001, the district's population was 2.44 million; by 2011, it had increased to 3.01 million, indicating a growth rate of 23.15%. This gain, albeit less than the 30.83% increase observed from 1991 to 2001, nonetheless signifies a substantial surge. This research only examines the Raiganj subdivision within the Uttar Dinajpur district of West Bengal, which includes four community development blocks: Raiganj, Hemtabad, Kaliaganj, and Itahar. The fast growth can be ascribed to several interconnected reasons, such as elevated fertility rates, significant migratory patterns, and restricted availability of family planning tools.

These processes have created a multifaceted socioeconomic and environmental landscape in the area, affecting its growth trajectory. Its historically elevated fertility rate is the critical factor driving population increase in the Raiganj subdivision (Bhatia, 1984). This rural territory, where a significant segment of the population relies on agriculture, often exhibits higher birth rates than urbanized or developed regions. Factors include restricted educational access, particularly for women, insufficient understanding of family planning techniques, and socio-cultural norms promoting more prominent families, contributing to ongoing population expansion. The health infrastructure and outreach initiatives in rural regions are inadequately established, constraining the district's ability to lower fertility rates. Migration is a significant element contributing to the increase of subdivision populations. Raiganj subdivision borders the Indian state of Bihar and has an international boundary with Bangladesh. This strategic position has resulted in substantial migration influxes from adjacent Indian states and across the international boundary. Numerous persons relocate for improved lifestyles, economic prospects, and social stability, increasing the district's population. Internal migration in India, propelled by economic inequities, contributes to the influx of migrants into the Raiganj subdivision seeking agricultural or informal sector employment. The Raiganj subdivision is primarily rural, with agriculture as the principal source of employment for its inhabitants. This agrarian economy often relies more on physical labour, historically resulting in more prominent families supporting agricultural endeavours. The sluggish industrial and economic advancement rate in the region constrains income diversification, compelling many individuals to persist in conventional subsistence agriculture. Population expansion continues without economic diversification, linked to cultural and economic patterns inherent in rural living.

Study Region

Raiganj subdivision, situated in the Uttar Dinajpur district of West Bengal, India, is positioned between latitudes 25° 11' N and 26° 49' N and longitudes 87° 49' E and 90° 0' E, encompassing four community development blocks Raiganj, Hemtabad, Kaliaganj, and Itahar (Census Governor, 2011). It functions as the administrative heart of the district, with Raiganj as its headquarters. The area is primarily agricultural, cultivating crops such as rice, wheat, and jute while accommodating small-scale industry. The subdivision has the Raiganj Bird Sanctuary, renowned for its many migrating birds. The Raiganj subdivision, next to Bangladesh to the east, serves as a center for trade, business, and cultural endeavors in northern West Bengal.

Objectives

(1) To analyze the growth of population density and dwelling density
(2) To analyze the prediction trend of population and dwelling density growth
(3) To assess the socio-environmental impact of population and dwelling density growth

Database and Methodology

The primary data source for this study is the Census of India 1981-2011. CD block-wise populations were obtained from both the Census of India and the Population Projection for India and States, 2011-2051

$$\text{Decadal population Growth rate} = \frac{\text{present year population} - \text{Past year population}}{\text{past year population}} \times 100$$

$$\text{Decadal population Growth rate} = \frac{\text{present year householde} - \text{Past year householde}}{\text{Past year householde}} \times 100$$

Trend analysis- Y=a + bx

Where x is the period, Y is the value of the item measured against time, a is the Y-intercept, and b is the slope of the line. Multiple tables were used to provide the necessary data. Choropleth maps of the population and household growth in 1981, 1991, 2001, 2011, and predict 2021, 2031, 2041 and 2051 were prepared using SPSS, the GIS platform ArcGIS 10.8 software.

Result and Discussion

Decade-Wise Population Growth

(a) Period of Steady Population Growth (1981–1991)

Throughout this decade, as seen in Table 1& Fig 1(a), all four areas experienced substantial Growth in population density. Increase rates varied between 20.74% and 27.62%, with Raiganj CD Block seeing the highest rate of increase. This indicates a phase of early urbanization and expansion, perhaps propelled by migration, Economic Growth, and natural population rises of 25.73%. Hemtabad CD Block, 24.15% increase Kaliyaganj Community Development Block. Itahar CD Block, with the lowest growth rate (20.74%), may have been less developed or less appealing for migration during this era, but it had significant expansion (Fig. 1 and Table-1).

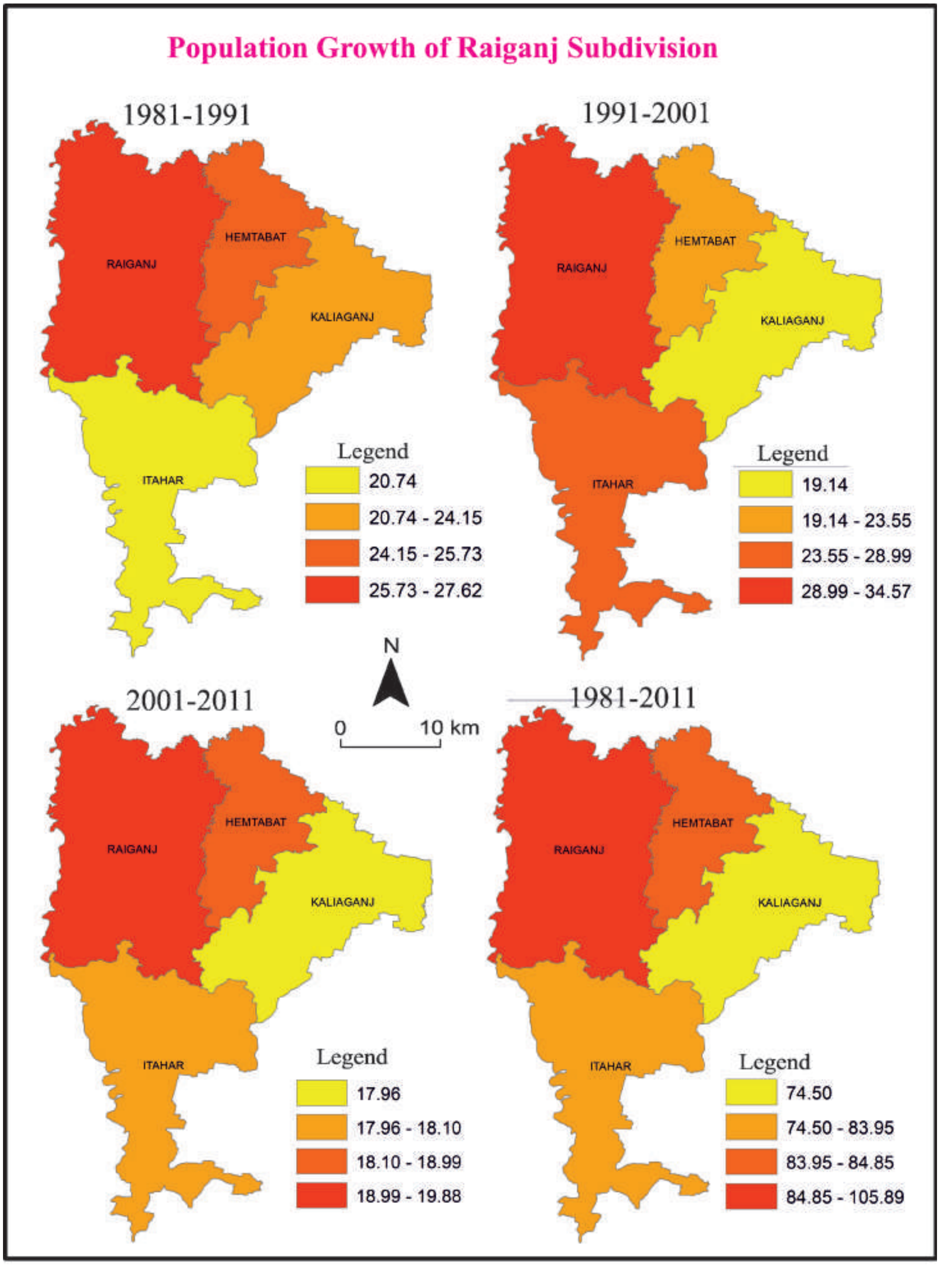
Population Growth of Raiganj Subdivision
1981-1991
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
20.74
20.74 - 24.15
24.15 - 25.73
25.73 - 27.62
1991-2001
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
19.14
19.14 - 23.55
23.55 - 28.99
28.99 - 34.57
N
0
10 km
2001-2011
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
17.96
17.96 - 18.10
18.10 - 18.99
18.99 - 19.88
1981-2011
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
74.50
74.50 - 83.95
83.95 - 84.85
84.85 - 105.89

Fig. 1

(b) Period of Rapid Expansion (1991–2001)

During the 1990s, Table 1& Fig 1(b) population density experienced significant Growth, with Raiganj CD Block leading at a 34.57% increase. In comparison, Itahar CD Block underwent a substantial transformation with a 29.00% rise, narrowing the gap with others. This rapid escalation in population density can be attributed to enhanced economic opportunities, industrial development, and urban migration. Hemtabad CD Block and Kaliyaganj CD Block, although still expanding, recorded comparatively lower increases of 23.55% and 19.15%, respectively, indicating a more measured growth in these regions.

(c) Period of Slowing Growth (2001–2011)

During the 2000s, population density growth across all regions significantly decelerated Table 1& Fig 1(c), with rates fluctuating between 17.97% and 19.89%. This slowdown indicates that the regions had attained more advanced stages of development, characterized by stabilized population influx. Raiganj CD Block exhibited the highest Growth at 19.89%, followed by Hemtabad CD Block at 19.00%. Conversely, Kaliyaganj CD Block (17.97%) and Itahar CD Block (18.11%) demonstrated the slowest Growth, likely signifying a shift from rapid urbanization to a more sustainable and regulated population increase.

(d) Cumulative Growth (1981–2011): Population Expansion:

The cumulative increase in population density over the 30 years is notable in Table-1 and Fig 1, particularly in Raiganj CD Block, which experienced a 105.90% rise in population. This signifies a more than twofold increase in population units, likely attributable to population growth, urban migration, and potential alterations in household composition (e.g., an increase in single-person or nuclear family households). All regions witnessed significant increases in population density during these three decades, with Hemtabad CD Block and Itahar CD Block also demonstrating considerable overall Growth (84.86% and 83.96%, respectively), while Kaliyaganj CD Block recorded the lowest cumulative Growth at 74.50%, indicating sustained demand for housing across all regions during this period.

Overall Trend

A distinct pattern of robust Growth in the 1980s, quick expansion in the 1990s, and sluggish Growth in the 2000s can be observed throughout the three decades.

Table-1: Population and Dwelling Density Growth Different Decades (1981-2011)

1981-1991			1991-2001			2001-2011			1981-2011		
Population (1981)	Population (1991)	Population Density growth (%)	Population (1991)	Population (2001)	Population Density growth (%)	Population (2001)	Population (2011)	Population Density growth (%)	Population (2011)	Population (1981)	Population Density growth (%)
207402	264688	27.62	264688	356192	34.57	356192	427038	19.89	427038	207402	105.90
76572	96276	25.73	96276	118952	23.55	118952	141549	19.00	141549	76572	84.86
125669	156021	24.15	156021	185896	19.15	185896	219298	17.97	219298	125669	74.50
159581	192682	20.74	192682	248555	29.00	248555	293563	18.11	293563	159581	83.96
Household (1981)	Household (1991)	Household density growth (%)	Household (1991)	Household (2001)	Household density growth (%)	Household (2001)	Household (2011)	Household density growth (%)	Household (2011)	Household (1981)	Household density growth (%)
36291	48886	34.71	48886	69927	43.04	69927	91397	30.70	91397	36291	151.84
14111	19463	37.93	19463	25018	28.54	25018	32054	28.12	32054	14111	127.16
22731	29738	30.83	29738	38446	29.28	38446	48675	26.61	48675	22731	114.13
28394	36592	28.87	36592	51013	39.41	51013	63732	24.93	63732	28394	124.46

This pattern represents the early phases of urban development, a population density explosion, and a subsequent natural stabilization as areas got developed and maybe ran out of room to accommodate more expansion.

Decade-Wise Household Growth

(a) Period of Moderate Household Growth (1981–1991)

Throughout this decade, all areas had moderate to substantial expansion in household density, shown Table 1& Fig 2 (a), signifying enhanced housing construction and maybe an increase in family units or smaller households. Growth rates varied between 28.87% and 37.93%, with Raiganj CD Block exhibiting a growth rate of 34.71%. Hemtabad CD Block has the most remarkable growth rate of 37.93%, followed by a growth rate of 30.83%. Kaliyaganj CD Block and Itahar CD Block have the lowest growth rate at 28.87%. This indicates that the rise in household units remained uniform across the areas during urbanization. The elevated rates indicate growing populations and the development of additional homes to satisfy demand.

(b) Period of Accelerated Household Growth (1991–2001)

From 1991 to 2001 showing that Table 1& Fig 2 (b), household density escalated significantly, particularly in Raiganj CD Block, which had a remarkable 43.04% increase, followed by Itahar CD Block with a 39.41% rise, Kaliyaganj CD Block with a 29.28% growth, and the lowest increase of 28.54% in Hemtabad CD Block. This indicates ongoing urbanization, migration, and maybe a transition to lower household sizes, necessitating an increase in housing units. The increase in Region 4, formerly the lowest in the last decade, accelerated, indicating quick expansion or enhanced housing infrastructure throughout this timeframe.

(c) Period of Slower, Yet Substantial Growth (2001–2011)

During the 2000s shown Table 1& Fig 2 (c), the rise of household density decelerated still remained substantial, fluctuating between 24.93% and 30.70%. Raiganj CD Block saw the greatest increase at 30.70%, followed by Hemtabad CD Block at 28.12% and Kaliyaganj CD Block at 26.61%. Simultaneously, Itahar CD Block saw a minimal growth rate of 24.93%. Notwithstanding the discrepancies, all locations exhibited remarkable advancement, universally indicating a favourable rising trajectory.

(d) Cumulative Growth (1981–2011): Exponential Household Expansion

The cumulative gain in household density during the 30 years is remarkable Table-1 and Fig. 2, particularly in Raiganj CD Block, which had a 151.84% increase in homes. This indicates a more than twofold increase in household units, likely attributable to population growth, urban migration, and potential alterations in household composition (e.g., an increase in single-person or nuclear family homes). All regions had significant increases in household density over the past three decades, with Hemtabad CD Block and Itahar CD Block demonstrating considerable overall growth rates of 127.16% and 124.46%, respectively, while the cumulative lowest Growth was 114.13%. The Kaliyaganj CD Block demonstrates that the need for housing persisted robustly over all locations during this timeframe (Fig. 2 and Table-2).

Overall Trend

Over three decades, household density steadily increased, with a notably accelerated rise between 1991 and 2001. This indicates a wider trend of urbanization, residential Growth, and maybe a transition towards smaller or more numerous family units. Although development decelerated in the 2000s, it remained significant, indicating that the areas continued to develop and satisfy housing demands, albeit at a more measured rate. All areas together more than quadrupled their household numbers from 1981 to 2011, highlighting the significant transformations in urban housing patterns throughout this timeframe.

Trend Analysis

The population projection under Table 2, 3 & Fig 3 Model_1 indicates a definitive increase trend throughout the 30 years from 2021 to 2051. In 2021, the anticipated total population is 1,555,546, with an upper confidence range of 1,725,870 and a lower confidence limit of 1,385,223, signifying a solid foundation for future Growth. By 2031, the population is projected to reach 1,780,233, indicating a growth of 224,687 inhabitants, with upper and lower confidence limits of 1,972,124 and 1,588,342, respectively. Elements like migration and natural population growth propel this expansion. By 2041, the projected population is expected to exceed 2 million, reaching 2,004,920, with an upper estimate of 2,216,215 and a lower estimate of 1,793,625. This notable milestone signifies an ongoing trend of urbanization and Growth. By 2051, the population is anticipated to reach 2,229,606, reflecting a total increase of 674,060 over thirty years, with upper and lower

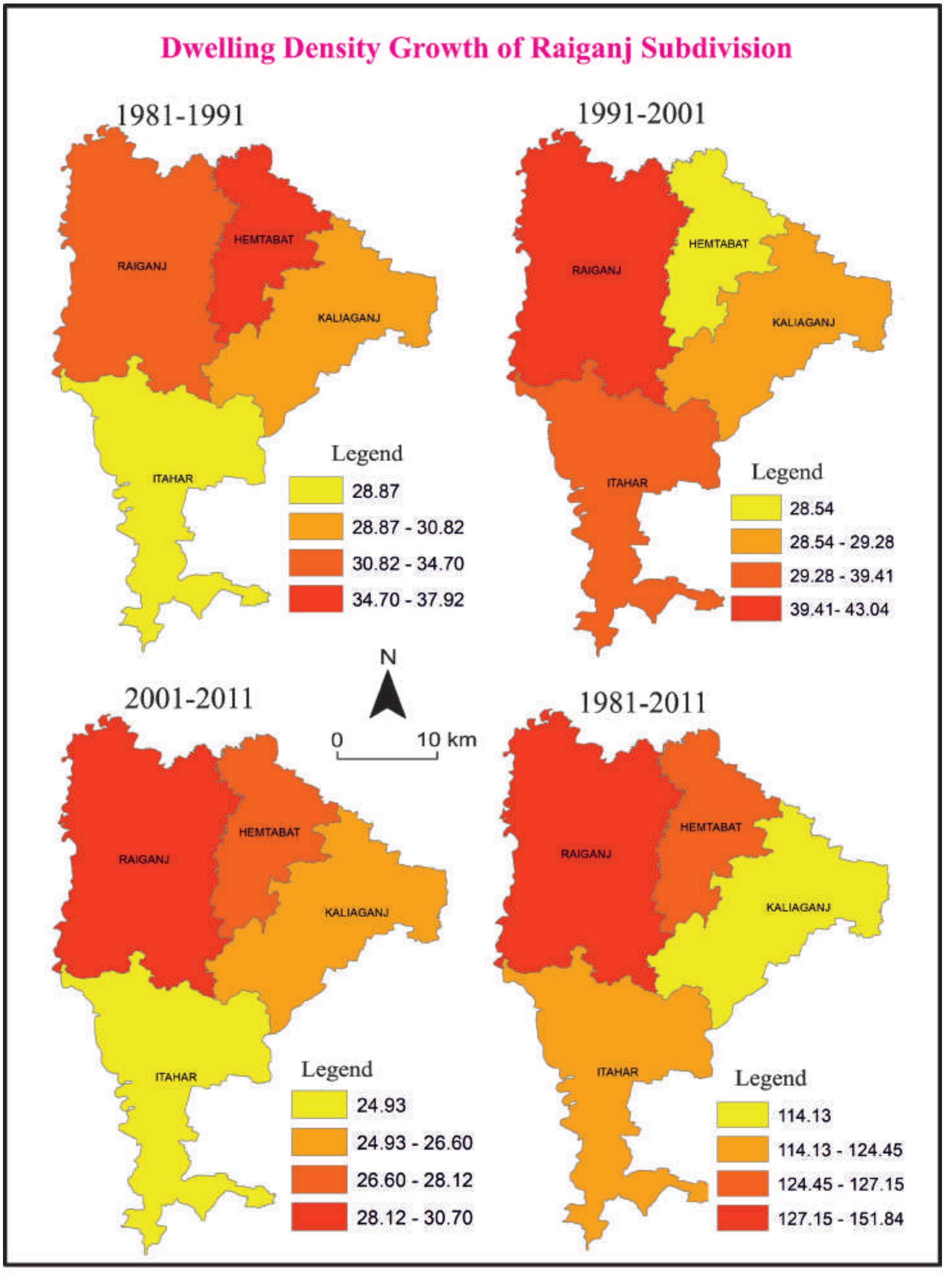
Dwelling Density Growth of Raiganj Subdivision
1981-1991
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
28.87
28.87 - 30.82
30.82 - 34.70
34.70 - 37.92
1991-2001
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
28.54
28.54 - 29.28
29.28 - 39.41
39.41- 43.04
N
0 10 km
2001-2011
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
24.93
24.93 - 26.60
26.60 - 28.12
28.12 - 30.70
1981-2011
RAIGANJ
HEMTABAT
KALIAGANJ
ITAHAR
Legend
114.13
114.13 - 124.45
124.45 - 127.15
127.15 - 151.84

Fig. 2

confidence intervals of 2,458,692 and 2,000,520, respectively. This estimate underscores the necessity for strategic planning to tackle the difficulties and possibilities arising from the demographic increase, ensuring sufficient infrastructure and services are established to accommodate the increasing population (Fig. 3 and Table-3 and 4).

Table-2: Total Population and Total Household Raiganj Subdivision (1981-2011)

Year	No. Population	No. Household
1981	669108	118677
1991	851924	171568
2001	1130654	223659
2011	1325664	285045

Table-3: Predict Different Decade Population Increasing

Forecast					
Model		2021	2031	2041	2051
Total population-Model_1	Forecast	1555546	1780233	2004920	2229606
	UCL	1725870	1972124	2216215	2458692
	LCL	1385223	1588342	1793625	2000520

Table 4: Predict Different Decade Household Increasing

Forecast					
Model	2021	2031	2041	2051	
No_HH-Model_1	Forecast	340501	395957	451413	506869
	UCL	362664	427301	489801	551196
	LCL	318338	364613	413025	462542

Source: Author

The household projection under Model_1 reveals a substantial rising trajectory from 2021 to 2051, commencing with 340,501 households in 2021. The projection indicates upper and lower confidence limits (UCL and LCL) of 362,664 and 318,338, respectively, implying a robust beginning foundation with growth potential. By 2031, the household count is projected to reach 395,957,

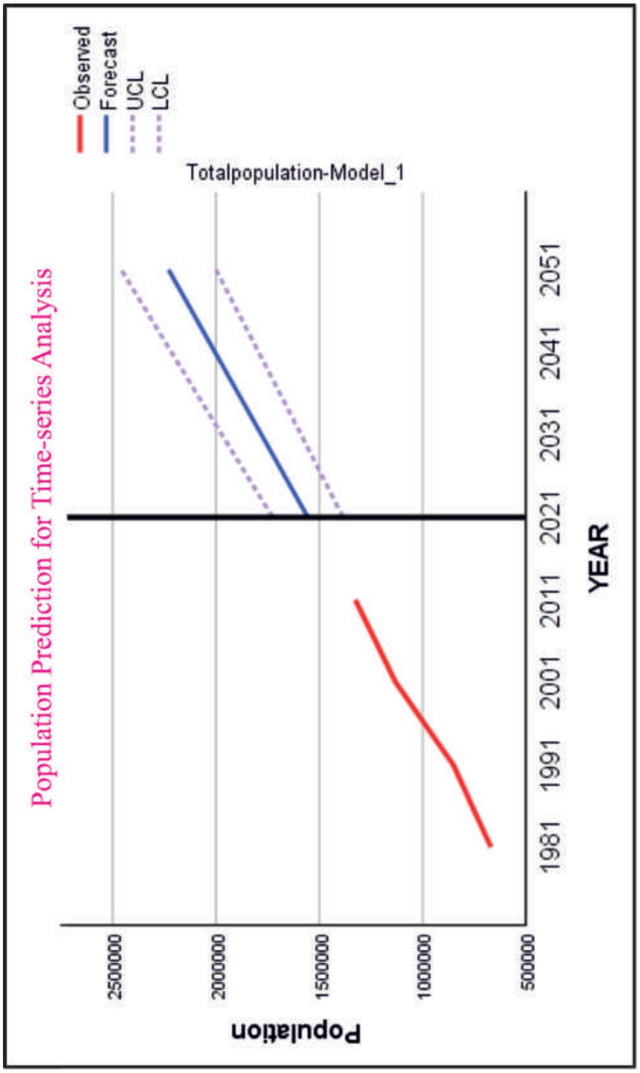
Population Prediction for Time-series Analysis
Observed
Forecast
UCL
LCL
Totalpopulation-Model_1
Population
2500000
2000000
1500000
1000000
500000
1981
1991
2001
2011
2021
2031
2041
2051
YEAR

Fig. 3

representing an increase of 55,456 households, with upper and lower confidence limits of 427,301 and 364,613, respectively, underscoring the persistent need for housing and the Growth of residential units. The estimate for 2041 indicates that the number of households is expected to reach 451,413, demonstrating substantial Growth, with upper and lower bounds of 489,801 and 413,025, respectively. By 2051, the total number of households is projected to reach 506,869, reflecting an increase of 166,368 households during the 30 years, with confidence intervals of 551,196 and 462,542. The persistent rise highlights the imperative for thorough planning in housing, infrastructure, and community services to sufficiently accommodate the increasing number of households, ensuring that future residential demands are fulfilled sustainably (Fig. 4).

Socio-environmental Impact

(a) Pressure on Resources

The swift population increase has significantly strained the district's natural resources, such as land, water, and forests. A substantial transformation of wooded and uncultivated land into agricultural land has occurred, as most of the population depends on agriculture to satisfy the increasing food demand. The Growth of agricultural land has resulted in deforestation and soil depletion, exacerbating environmental degradation. The escalating demand for water, essential for human consumption and agricultural use, has resulted in water shortages, causing groundwater levels in certain regions to decline owing to excessive extraction.

(b) Urbanization and Infrastructure Development

Although the Raiganj subdivision is primarily rural, its urban areas face increasing challenges due to population migration. Towns in the area, like Raiganj, are undergoing fast urbanization, resulting in the proliferation of congested slums and informal settlements. These regions experience deficient infrastructure, inadequate housing, substandard sanitation, and inconsistent access to potable water. The district's educational and healthcare institutions are overloaded and unable to meet the demands of the expanding population. This infrastructure burden intensifies public health challenges and obstructs educational progress, which may otherwise aid in mitigating population increase.

(c) Rising Unemployment and Poverty

The elevated population density and restricted work prospects have increased poverty in the Raiganj subdivision. The district's economic foundation

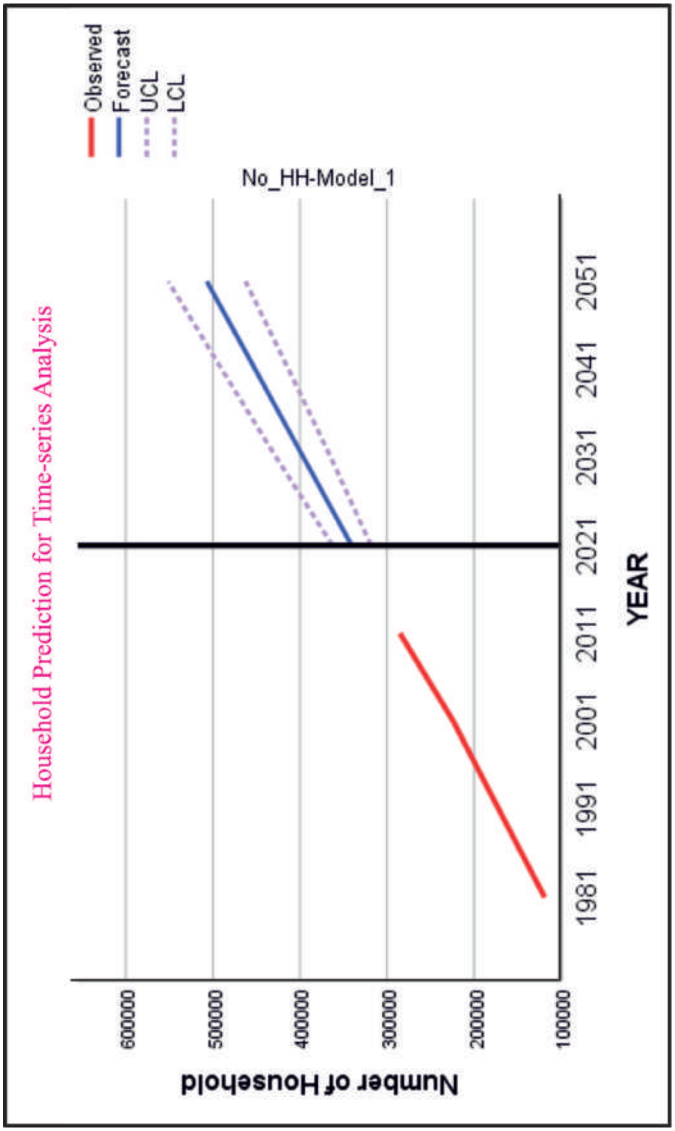
Household Prediction for Time-series Analysis
No_HH-Model_1
Observed
Forecast
UCL
LCL
Number of Household
600000
500000
400000
300000
200000
100000
1981
1991
2001
2011
2021
2031
2041
2051
YEAR

Fig. 4

is predominantly agricultural, with little industrial or service sector employment opportunities. Consequently, several individuals remain ensnared in low-income, subsistence agriculture, with no prospects for upward mobility. The absence of industrialization and employment diversification makes a significant percentage of the population susceptible to economic shocks, such as inadequate harvests and reliance on government assistance. Furthermore, the disproportionate allocation of resources has exacerbated the disparity between the affluent and the impoverished, with those in rural regions or urban slums suffering the most from the district's poverty.

(d) Health Challenges

The rapid increase in population and insufficient healthcare facilities have exacerbated the district's public health issues. Overcrowded living circumstances, especially in urban slums, exacerbate the transmission of infectious illnesses such as TB and diarrhea. Malnutrition is widespread, especially among youngsters, owing to the district's elevated poverty rate. Access to healthcare services is frequently restricted, particularly in rural regions, where hospitals and clinics are sparse. The deficiency in healthcare infrastructure obstructs initiatives aimed at decreasing baby and maternal death rates and managing illness proliferation. The district's elevated fertility rate and insufficient healthcare facilities exacerbate the strain on an already vulnerable public health system.

(e) Educational Barriers

The population expansion in the Raiganj subdivision has taxed its educational resources. Educational institutions are congested, and the calibre of instruction is frequently substandard, especially in rural regions. Elevated dropout rates, especially among females, persist as a significant concern. Inadequate education, particularly about health and family planning, will likely result in unchecked population expansion in the district. Educational obstacles restrict work prospects for the district's youth, thus continuing the cycle of poverty and economic stagnation.

Environmental Impact

(a) Deforestation and Land Degradation

The need for land for homes and agriculture rises with population density, which causes deforestation and the loss of natural ecosystems. In addition to endangering biodiversity, removing trees for agriculture causes soil erosion and depletion. Deforestation impacts the district's water cycle, raising the danger of floods and droughts and upsets the equilibrium of nearby ecosystems, resulting in a decrease in animals and native plants.

(b) Water Scarcity

The district's water supplies are extremely strained due to the expanding population. The district's primary agriculture industry depends mainly on groundwater, and over-extraction has caused water levels to drop. Water shortages are becoming increasingly common in some places, which has an impact on drinking water supplies as well as agriculture. In the coming years, this problem will probably get worse due to poor water management techniques and increased population demands.

(c) Pollution

The district's population growth and the fast growth of metropolitan areas have resulted in a rise in pollution, especially in waste management. Due to insufficient waste disposal infrastructure in many communities, trash is frequently thrown into rivers or piled up in open spaces, polluting the water. Another issue is air pollution, which is exacerbated by an increase in automobiles and the use of biomass for cooking in rural areas.

(d) Future Outlook and Challenges

As the population of the Raiganj subdivision continues to increase, sustainably managing this growth will be a significant challenge for the district. In the absence of measures to curtail population expansion and alleviate its effects, the area faces the peril of descending into a cycle of escalating poverty, environmental deterioration, and social turmoil. Essential intervention areas encompass enhancing access to family planning and healthcare services, diversifying the economy to generate other job options beyond agriculture, and investing in infrastructure to accommodate the expanding population. Moreover, it is imperative to use more sustainable agricultural techniques to mitigate the environmental repercussions of farming. Efforts in water conservation, afforestation initiatives, and enhancements in waste management systems are crucial for safeguarding the district's natural resources for future generations.

Conclusion

The Raiganj Sub-division has undergone significant expansion in population and housing density, indicating its rising prominence as a regional centre.

Intricate socio-environmental issues accompany this expansion. The increasing population has intensified housing demand, transforming agricultural and green lands into residential zones jeopardizing the region's natural equilibrium. This tendency exerts considerable strain on local infrastructure, including water supply, waste management, and transportation networks, all of which are challenged to accommodate the growing population. The diminution of green cover and escalating pollution levels lead to habitat destruction and decreased biodiversity. Rapid urbanization has resulted in societal inequities in housing availability and cost, with lower-income groups encountering significant challenges in obtaining suitable accommodation. Moreover, unanticipated or inadequately managed expansion intensifies problems such as traffic congestion, sanitation, and public health hazards. Confronting these difficulties necessitates a cohesive strategy emphasising sustainable design, green infrastructure, equitable housing policy, and enhanced resource management. By promoting equilibrium between development and environmental conservation, Raiganj can secure more resilient, inclusive, and sustainable progress in the future.

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COMPARATIVE ANALYSIS OF ENERGY CONSUMPTION IN DIESEL VS ELECTRIC PUMPS USAGE FOR AGRICULTURAL IRRIGATION IN GURUGRAM AND JHAJJAR DISTRICT OF HARYANA

Ankit Duhan, Dr. Isha Kaushik and Jyoti

Abstract

The primary goal of the current research paper is to examine the distribution of energy consumption in Haryana's agricultural sector, district-wise for the period 2006 to 2023. The Department of Economic and Statistical Analysis (DESA), Government of Haryana, publishes the Statistical Abstract of Haryana, from where the study's data has been collated. The entire cropped area and the Standard Energy Conversion Table created by TERI were used to calculate the energy usage in a hector. According to data analyzed, the State used 1,644.920 GWh of energy wherein chemical energy accounted for over 90% of global energy consumption, with human energy coming in second with 7 percent, electrical energy at 1.7 percent, and mechanical energy at 1.3%. Jhajjar district has used the least amount of energy, whereas Gurugram district has used the maximum. Comparing the utilization rates, the advantages and disadvantages of each type of pump set have been weighed economically, besides determining how it affects the environment, data from both districts will be gathered and examined. The study examines the advantages and disadvantages of this shift, such as grid stability, rural areas' access to electricity, and the possibility of incorporating renewable energy sources. The predicted scope lies in the predicted outcomes giving the stakeholders and legislators important information they can use to create energy policies that work towards supporting sustainable farming methods in Haryana.

Introduction

In India, groundwater irrigation has been crucial to the Green Revolution's success, especially in the original States that made up western Uttar Pradesh, Haryana, and Punjab. Around 80% of Haryana's entire land area is used for

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agricultural purposes. About 84% of the entire cultivable land is dependent on irrigation systems. Groundwater irrigation is the most effective type of irrigation used in the Green Revolution technologies (Moench, 2003). According to certain studies, the crop yield from areas watered by surface sources was observed to be half to one-third times lower than those from places irrigated by groundwater (Dhawan 1995). In Haryana, the need for protective irrigation has grown annually, as has the reliance on pumping groundwater for irrigation. However, as the earth's surface has been drying up due to sustained climate change, groundwater extraction needs to continue through tube wells. The State has 8,40,000 recorded tube wells that draw water from the earth's surface. In the instance of Haryana, the anticipated annual fall in ground water level was 35 cm (Chatterjee and Purohit, 2009). The State's subsurface water depth doubled between 1999 and 2017 (Amar Ujala, 16 April, 2017). A 2011 National Academy of Agricultural Sciences study stated, "In Haryana, only 37 percent of the water is exploited within the safe limits while 14 percent of over-exploitation has reached a semi-critical to a critical stage." It also stated, "Water-table in 82 percent area of Punjab and 63 percent of that in Haryana has gone down substantially."

Objectives

To analyze the availability and usage of diesel vs electric pumps in agricultural irrigation in Gurugram and Jhajjar district of Haryana.

Database and Methodology

With a primary focus on analyzing the energy consumption patterns between diesel and electric pumps in agricultural irrigation across districts in Haryana from 2006 to 2023, the study will employ a comparative and descriptive research design. The utilization of a comparative approach facilitates an assessment of the two categories of energy sources, scrutinizing their effects on the economy, environment, and operations. The process of gathering data relied on secondary data sources. The Department of Economic and Statistical Analysis (DESA), Government of Haryana, publishes the Statistical Abstract of Haryana each year, from which statistical data has been collected. This document offers historical information on the trends and patterns of energy usage for both electric and diesel pumps. The energy usage metrics for diesel and electric pumps across various districts were standardized through the use of energy conversion data from TERI (The Energy and Resources Institute), specifically the Standard Energy Conversion Table. To enhance the comprehension of adoption trends, supplementary publications and reports from the agricultural department of Haryana as well as energy audits have also been examined. Districts like Jhajjar and Gurugram, which are representative of both high and low energy usage regions, have been selected by using the purposive sample technique. This will make it possible to compare in detail how various districts have chosen to use diesel or electric pumps and how this has impacted the sustainability and productivity of agriculture. For a more in-depth scrutiny the districts will be categorized according to economic and geographic criteria. Gurgaon's water system scene exhibits a momentous change in siphon set use, especially leaning in favour of electric over diesel-fuelled choices. By examining the Diesel-to-Electric Siphon Set Proportion, determined as:

$$Ratio = \frac{Number\ of\ Diesel\ Pump\ Sets}{Number\ of\ Electric\ Pump\ Sets}$$

There are 1,062 diesel siphon sets as compared to in contrasted with 19,007 electric ones. For every twenty electric siphon sets, there is one diesel siphon sets. This unmistakable distinction underscores the strength of electric siphon sets in the locale. While considering the complete number of siphon sets, which adds up to 20,069, electric siphons make up a total of 94.7 percent while diesel siphons represent a mere 5.3 percent. This higher inclination for electric water system arrangements flags a huge change in Gurgaon district’s manner of dealing with agriculture-based irrigation (Fig. 1).

Result and Discussion

The number of diesel sets has grown over the past almost two decades from 233055 in 2006 to 279156 in 2023 showing an increase of about 50000 diesel pump sets. On the other hand, the number of electric pump sets increased from 635520 in 2006 to 832938 in 2023 showing an increase of over 200000 sets. The number of pump sets that are distributed across the two selected districts of Jhajjar and Gurugram for the period from 2006 to 2023 has been shown in the Table-1 and Fig. 1 and 2).

Environment Implication, Air Pollution and Water Pollution

The irrigation techniques used for agriculture in Jhajjar and Gurugram have had a significant impact on the environment, especially when it comes to greenhouse gas Perfluorocarbon (C2F6, CF4) emissions and how they affect climate change directly or indirectly in the short term and the long term (Fig. 1 and Table-1). Even though there has been a noticeable shift in Gurugram towards electric

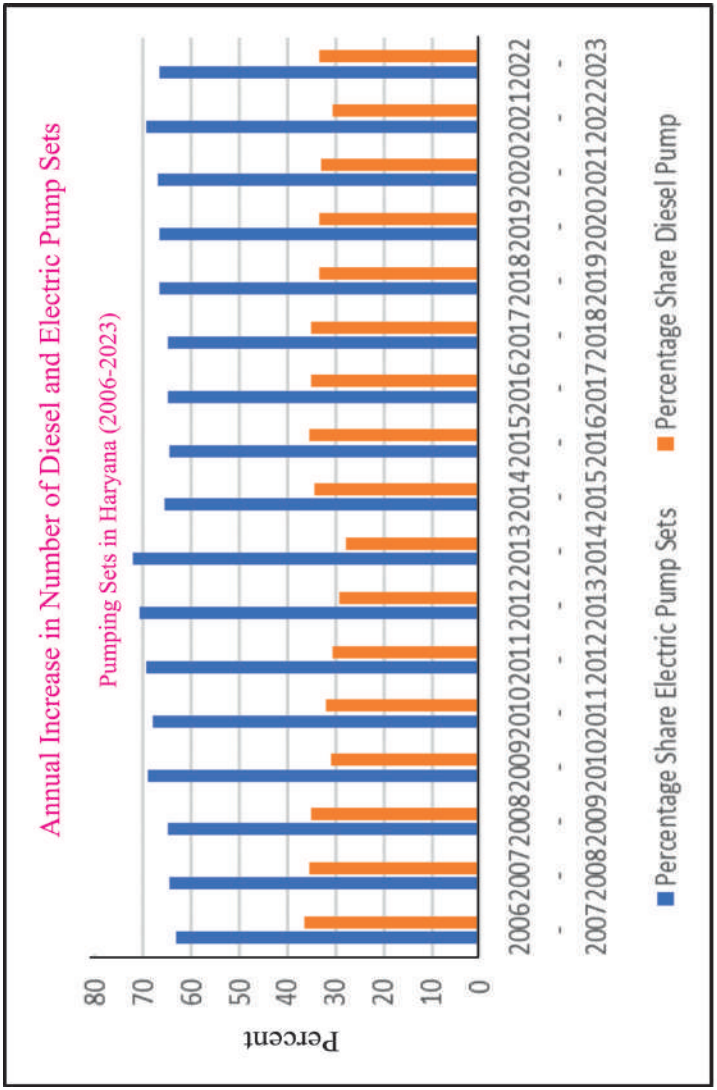
Annual Increase in Number of Diesel and Electric Pump Sets
Pumping Sets in Haryana (2006-2023)
Percent
0
10
20
30
40
50
60
70
80
2006-2007
2007-2008
2008-2009
2009-2010
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
2022-2023
Percentage Share Electric Pump Sets
Percentage Share Diesel Pump

Fig. 1

Table-1: Pumping Sets in Selected Districts of Haryana (2006-2023)

Year	Diesel Pump Sets Jhajjar	Diesel Pump Sets Gurugram	Total	Electric Pump Sets Jhajjar	Electric Pump Sets Gurugram	Total
2006-2007	30130	1472	31602	5784	21551	27335
2007-2008	30450	1488	31938	5862	21860	27722
2008-2009	34063	736	34799	6447	22207	28654
2009-2010	22770	636	23406	6667	22737	29404
2010-2011	22288	623	22911	7024	23953	30977
2011-2012	21700	607	22307	7308	24926	32234
2012-2013	21218	595	21813	7593	25899	33492
2013-2014	20794	583	21377	8600	25736	34336
2014-2015	31791	595	32386	9019	26058	35077
2015-2016	31791	595	32386	9019	26058	35077
2016-2017	31791	489	32280	9514	13913	23427
2017-2018	33924	574	34498	6900	15279	22179
2018-2019	33924	574	34498	6900	15279	22179
2019-2020	33614	1062	34676	6828	19007	25835
2020-2021	33614	1062	34676	6828	19007	25835
2021-2022	16261	3809	20070	11837	18592	30429
2022-2023	32009	3809	35818	21364	18592	39956

Source: Authors

pumps in the district due to the avoidance of the continuous reliance on diesel for irrigation which raises the levels of carbon dioxide emissions. Significant volumes of carbon dioxide are released during the burning of diesel, which aggravates climate change and its effects, which include modified weather patterns, more frequent flooding, and longer droughts. These modifications have a negative impact on agricultural output and tend to jeopardize food security. Jhajjar district, on the other hand, faces even bigger environmental problems due to its dependency on diesel pumps (Fig. 2). Diesel smoke emits pollutants that are bad for human health as well as the environment. Long-term exposure to diesel pollution can cause serious problems including lung cancer and heart disease in addition to chronic respiratory disorders like bronchitis and asthma. Another major risk to Jhajjar's soil and water quality is fuel leaks from pumps. Reduced agricultural output and the possibility of dangerous materials entering the food chain are two consequences of contaminated soil. Exposure to contaminated soil can cause headaches, nausea,

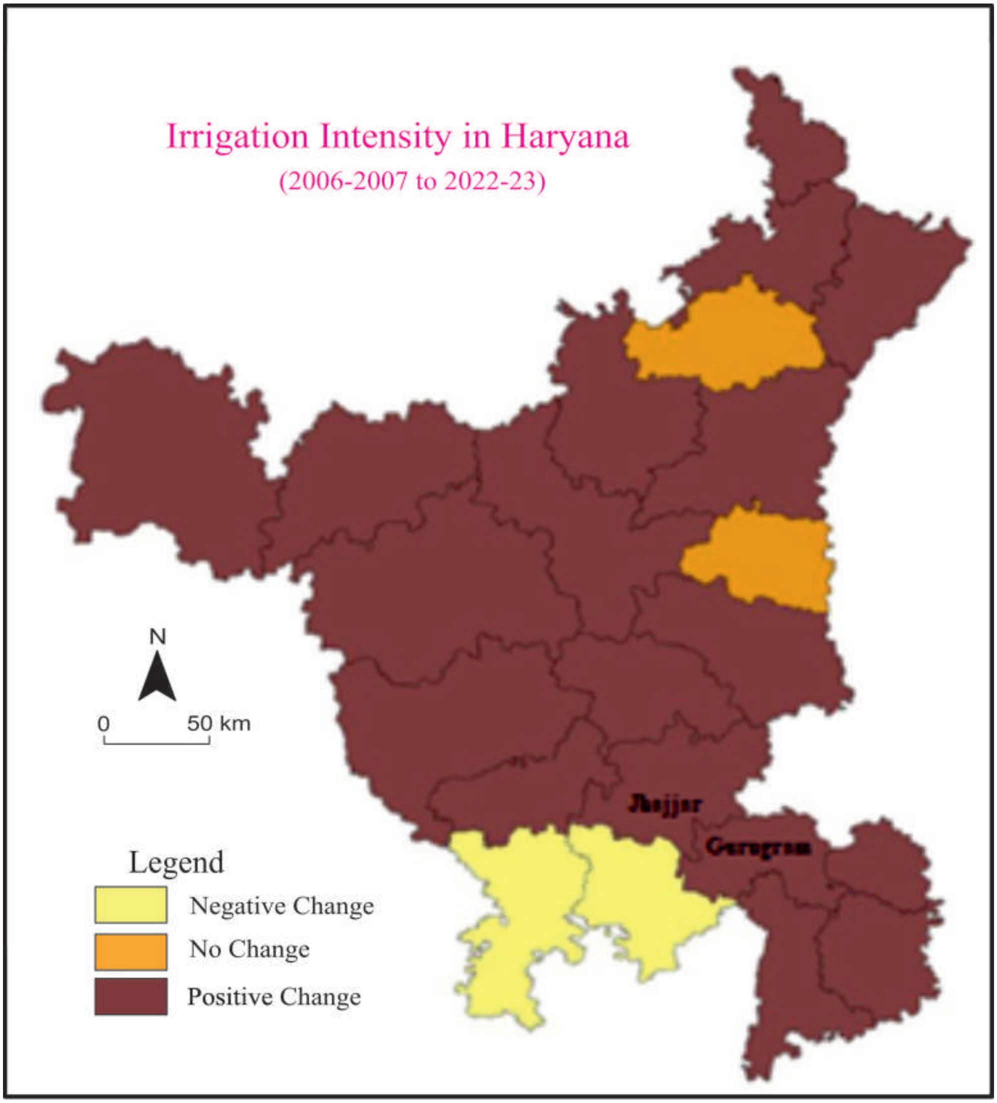
Irrigation Intensity in Haryana
(2006-2007 to 2022-23)
N
0
50 km
Jhajjar
Gurugram
Legend
Negative Change
No Change
Positive Change

Fig. 2

and vomiting, among other health problems. Moreover, diesel spills have the potential to contaminate adjacent water supplies, resulting in the spread of dangerous waterborne diseases like cholera, dysentery, diarrhea, hepatitis-A, typhoid, and even polio. Seriou's repercussions may arise from these disorders, especially for older people and children who are already vulnerable and susceptible. The agricultural methods used in Jhajjar and Gurugram highlight the critical need for concerted legislative initiatives to address these recurrent threats to public health, soil contamination, and greenhouse gas [GHG] emissions. Policymakers can promote healthier communities and a more sustainable environment by granting a higher priority to investments in sustainable technologies and implementing rules that limit the use of diesel. In the long run, this will benefit both public health and agriculture.

Policy Implications

It is possible to apply a number of different tactics in order to improve the operating efficiency of electric pumps in both Gurugram and Jhajjar. With an overall efficiency of 75 percent to 85 percent as opposed to diesel pumps' 18 percent to 35 percent, electric pumps are typically more efficient than diesel pumps. Electric pumps are a more environmentally friendly option for agricultural irrigation because of their increased efficiency, which results in more efficient water delivery and lower energy use. The use of electric pumps is more environmentally benign and in line with sustainability goals than diesel pumps, which fuel air pollution, global warming, and soil and groundwater contamination. Furthermore, electric pumps provide greater control freedom. With electric motors instead of diesel pumps, it is simpler to install pump controllers and variable speed controls, enabling more accurate irrigation system management. Additionally portable, electric submersible pumps are simpler to move around a job site and because of its mobility, farmers are able to swiftly and effectively modify their irrigation system in response to shifting field and crop conditions. The incorporation of renewable energy sources, such as solar electricity, have the potential to significantly improve the sustainability of electric irrigation systems. It is possible for farmers to decrease their reliance on fossil fuels and minimize their operational expenses by making use of renewable energy sources. Additionally, training programs for farmers can enhance the benefits of electric pumps by instructing them on the most effective methods for water management and energy efficiency. Policymakers have the ability to dramatically reduce their dependency on diesel pumps by concentrating on these techniques in both Gurugram and Jhajjar. This will in turn address the issues of pollution and global warming while simultaneously supporting sustainable agricultural practices. The implementation of this all-encompassing strategy will not only improve the state of public health, but will also boost the general quality of life in these districts.

Social Implications

It is important to note that the transition from diesel to electric pumps has substantial repercussions for the communities of Gurugram and Jhajjar. When it comes to farming techniques in Gurugram, the growing utilization of electric pumps is frequently linked to modernization and an increase in the efficiency of these practices. This transformation has the potential to facilitate the empowerment of farmers by lowering their reliance on fossil fuels, resulting in reduced operational costs and increased control over their irrigation systems. Additionally, the reduction in air pollution results from decreased diesel use adds to better health outcomes for communities, resulting in fewer expenses for healthcare and an overall improvement in the quality of life. The persistent reliance on diesel pumps in Jhajjar can make existing social disparities even more pronounced. Farmers who are unable to provide the financial resources necessary to switch to electric pumps may be subject to rising operational costs as well as the health problems connected with diesel emissions. Not only does the pollution that diesel pumps produce have an impact on their health, but it also has the potential to reduce the productivity of their crops, which can put a strain on their economic sustenance. These circumstances have the potential to extend the distance between those who are able to invest in environmentally friendly technologies and those who are unable to do so, resulting in differences in agricultural productivity and economic stability. The use of electric pumps in both districts has the potential to result in increased community engagement and understanding of environmental concerns. The adoption of cleaner technology by farmers may result in an increase in the number of opportunities for collaboration with local stakeholders, such as the government, non-governmental organizations (NGOs), and community organizations, in order to promote environmentally responsible behaviors and sustainable practices. If these factors are addressed through the implementation of supportive policies and initiatives, it will be possible to establish an agricultural environment that is egalitarian and sustainable in both Gurugram and Jhajjar.

Economic Implications

Diesel fuel pumps frequently incur larger expenditure in Gurugram and Jhajjar, including expenses associated with fuel, maintenance, and the potential health costs that are incurred as a result of pollution. Farmers' finances can be put under strain as a result of these increased operational expenditures, particularly for those farmers who have limited resources. There are a few different approaches that can be taken in order to cut down on these operational costs. To begin, switching to electric pumps typically results in reduced fuel expenditures when compared to diesel fuel over the course of time. This is because electricity is typically more affordable than diesel fuel. It is possible for policymakers to make this transition easier by offering financial incentives, such as subsidies or loans with low interest rates, for the purchase and installation of electric pumps. In the long run, the savings on fuel and maintenance prove to be sufficient to compensate for this initial outlay. The implementation of training programs for farmers on energy-efficient techniques and the correct maintenance of electric pumps can assist in maximizing the performance and longevity of these pumps ultimately minimizing the expense of operations over the long run. It is possible to reduce the financial strain that is placed on farmers through the implementation of policies and programs that are supportive. This will result in agricultural practices that are more sustainable and will contribute to increased economic stability in both Gurugram and Jhajjar.

Environmental Regulations

Environmental rules in Haryana, especially in the districts of Jhajjar and Gurugram, concerning the usage of electric and diesel pumps for agricultural irrigation have been made to decrease the adverse environmental impact of the misuse of these energy sources. Diesel pumps are major contributors to air pollution and greenhouse gas emissions; hence, the Haryana State Pollution Control Board (HSPCB) has set stringent emission rules for these pumps. These regulations mandate routine maintenance and inspections to guarantee compliance to safeguard the neighboring communities from the noise pollution caused by diesel engine operations, Diesel pumps have a far greater environmental impact than electric pumps, particularly in metropolitan regions like Gurugram where air quality is a major concern. Electric pumps, on the other hand, help reduce greenhouse gas emissions and enhance air quality. The State intends mitigating climate change and resolving health problems by promoting electrical alternatives and implementing stronger rules on the use of diesel pumps. The switch from diesel to electric pumps has had significant effect on global warming policy. To further reduce greenhouse gas emissions policymakers must prioritize investments in renewable energy sources like solar or wind power to power electric pumps. In addition, plans for managing water and energy should be coordinated to prevent other environmental risks, especially those arising threats that are being made worse by the electricity needed for irrigation. Effective execution of these measures can promote replication in other areas with comparable problems, highlighting the possible advantages of switching to greener energy sources. It is possible to increase the efficiency of electric-powered pumps in a number of ways. Choosing the appropriate pump size is one of the most important steps. Energy waste can be avoided by using a pump that is the right size for the particular watering needs. While tiny pumps may not function adequately, resulting in deficiencies, the oversized pumps frequently use much more electricity than is necessary. Last but not least, teaching farmers on optimal pump maintenance and operation procedures might result in a more effective usage of electric pumps. By optimizing pump performance, agricultural practices can reduce overall energy consumption. This can be achieved by learning how to operate pumps effectively. These techniques can help electric pumps operate more efficiently, which will save energy costs and improve sustainability.

Conclusion

The switch from diesel pumps to electric pumps for irrigation in both rural Jhajjar and metropolitan Gurugram constitutes a significant step towards the implementation of farming practices that are more environmentally friendly. In addition to cutting emissions and increasing air quality, this transition not only lessens the impact on the environment, but simultaneously enhances the economic efficiency by reducing the amount of money spent on operationalization and maintenance that is required. Through the utilization of technological breakthroughs, such as intelligent irrigation systems, farmers are able to maximize the utilization of water and increase the yield of their crops. The fact that this transformation is aligned with government measures to promote sustainable agriculture further emphasizes the significance of this change. The implementation of electric pumps helps to cultivate a more robust agricultural framework that is beneficial for both, the communities and the environment they inhabit. Such conducive steps are progressively developmental and can help pave the way for a more sustainable future in the agricultural sector.

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WOMEN'S PARTICIPATION IN FLORICULTURE: A CATALYST FOR ECONOMIC GROWTH IN NAGALAND

M. Caroline and Dr. Seema Tiwari

Abstract

Floriculture in Nagaland presents a promising opportunity for sustainable economic growth and livelihood enhancement in the region. Floriculture, with its growing market demand and low investment requirements, presents significant opportunities for enhancing rural livelihoods, particularly for women. In a state, where agriculture is the backbone of the economy, floriculture offers an alternative income source and a platform for women's economic empowerment. The study is conducted on women flower growers in Kohima district of Nagaland by using purposive sampling. It aims to explores how women's involvement in floriculture contributes to household income, generates employment, and overall improved their livelihood through a combination of field survey, questionnaire and interview. Furthermore, the studies identified some significant prospects as well as challenges women face in the sector. By shedding light on these dynamics, the research underscores the transformative potential of women in floriculture as a catalyst for women empowerment and economic growth in Nagaland.

Introduction

Flowers have captivated human throughout history of civilizations. Ancient Egyptians adorned their architectural marvels with floral designs, while Greek warriors and Olympians were honored with intricate floral wreaths for their victories. Floriculture, a branch of horticulture, that involves the cultivation of ornamental plants, flowering plants, foliage plants, medicinal plants, cut flowers, bulbs, seeds, and seedlings (Gauchan, et al., 2009). This field is emerging as a diversified industry, as flowers and plants offered considerable aesthetic, social, environmental, and economic value. Floriculture comprises a wide variety of plants and planting materials, that includes commercial production of cut and loose flowers,

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potted plants, foliage, bulbs, seeds, as well as landscape and indoor plants. Today, floriculture is recognized as a highly lucrative profession, generating significantly higher returns per unit area compared to other horticultural crops (Datta, 2019) Therefore, making commercial floriculture as one of the most profitable ventures worldwide. Floriculture presents a sustainable avenue for livelihood, providing diverse career opportunities for both skilled and unskilled workers. By capitalizing on local resources and strengths, it offers various pathways for income generation. In the context of globalization, floriculture has emerged as a significant aspect of agricultural diversification. It has evolved into a viable and profitable alternative to conventional farming, with the capacity to foster self-employment among small-scale and marginal farmers (Nath & Datta, 2022). India's floriculture sector has shifted from traditional flowers towards cut flowers for export potential. Floriculture is designated as a sunrise sector by Government of India giving 100% export-oriented status. It is one of the fastest-growing sectors of agriculture, witnessing very significant transformation in the production and marketing of high-value crops in India. The global revenue generated by the floriculture industry has motivated the Indian government to promote this sector, by recognizing it as a key driver of economic growth (De and Singh, 2016). The floriculture industry, regarded as a major contributor to foreign exchange earnings, has not only boosted income but also created vast employment opportunities in related sectors such as advanced transport services, pots, nursery supplies, planting tools, protection equipment, and packaging materials (Malhotra, 2017). Over the past two decades, many floriculture enterprises have been established, leveraging the government incentives to produce and export flowers to the global market in large scale.

The National Horticulture Board (NHB), Agricultural and Processed Food Products Export Development Authority (APEDA), National Bank for Agriculture and Rural Development (NABARD), and nationalized banks are the key financial resources for establishing the floriculture business in India. APEDA is responsible for export and its development, and the Government of India has recognized floriculture's potential by granting it 100% export-oriented industry status (APEDA, 2017). In 2020-21, flowers were cultivated on 322 hectares, producing an estimated 2,151.96 thousand tons of loose flowers and 828.09 thousand tons of cut flowers (National Horticultural Board, 2021). India exported 23,597.17 tons of floriculture products, valued at ₹771.41 crore/ $103.47 million. The Indian flower industry is estimated to be worth $400 million in retail and around $100 million in international trade. According to the Gross Value of Output (GVO) report for

Agriculture and Allied Sectors, the value of floriculture increased by 55% from ₹17,365.38 crore to ₹26,987.41 crore between 2019-20 in India. Floriculture exports grew by 48%, from ₹365.32 crore in 2011-12 to ₹541.61 crore in 2019-20, and further increased by 34%, from ₹575.98 crore in 2020-21 to ₹771.41 crore in 2021-22, signaling a promising future for the sector in India (National Horticultural Board, 2021).

Study Region

Nagaland is a state located in the northeastern region of India, which spans a geographical area of 16,579 square kilometers and has a population of 1,980,602 as per the 2011 census of India, making it one of the smallest states in the country. Geographically, it lies between 93°20'E and 95°15'E longitudes and between 25°6'N and 27°4'N latitudes. The state experiences a predominantly monsoon climate, characterized by high humidity levels. Annual rainfall averages between 1,800 and 2,500 millimeters, primarily received between May and September. Temperatures in the region vary from 21°C to 40°C. The terrain which is marked by lush forests, rolling mountains, picturesque valleys, and clear rivers and streams is a scenic beauty to behold. Nagaland, with its favorable agro-climatic conditions, fertile soil and rich natural resources is well-suited for producing high-quality flowers. Flower cultivation, which was once limited to small gardens and open spaces for recreation, has now evolved into a significant livelihood source in the state, with large-scale cultivation taking place under advanced technological systems. Over the past decade the state has seen tremendous increase in production, consumption, and marketing of flowers. This expansion has significantly enhanced the economic importance of the sector, and floriculture has become a key component of commercial agriculture. With growing awareness of its potential, today more individuals are involved in the floral business. The commercialization of floriculture in Nagaland began in 2004-05 under the Horticulture Mission for North East & Himalayan States (HMNEH), which leads to rapid development driven by the state's government Horticulture Mission. Table-1 shows the floriculture sector in recent years.

Objectives

(1) To explores how women's involvement in floriculture contributes to household income, generates employment, and overall improved their livelihood.
(2) To understand the prospects and challenges of floriculture in Nagaland

Table-1: Area and Production of Flowers in Nagaland (2016-2021)

Sl. No.	Year	Area (in‘00ha)	Cut flowers (in ’00 mt)
1	2016-17	0.05	6.18
2	2017-18	0.07	8.79
3	2018-19	0.04	24.40
4	2019-20	0.04	24.50
5	2020-21	0.06	32.32

Source: National Horticultural Board, Nagaland, 2021

Database and Methodology

The present research aimed to understand the role and participation of women in catalyzing economic growth of Nagaland. The study adopts a descriptive and exploratory design. The descriptive aspect focuses on profiling women engaged in floriculture, while the exploratory design looks into the challenges and prospects within this sector. The study was conducted with primary data collected during June 2024. 60 women flower growers were selected through purposive sampling in Kohima district of Nagaland. Structured interviews and questionnaires were used and are designed to capture demographic profile, women participation, economic development, challenges, and other aspects of floriculture practices within the Naga community. Moreover, secondary data such as government reports, census, research papers related to floriculture is used to supplement the primary data. Frequency distribution and percentages is used to show the data.

Result and Discussion

Floriculture is now one of the most thriving industries in Nagaland, generating an annual revenue of ₹1.50 to ₹2.00 crores and providing employment opportunities to thousands of women and youths. Initially, the State Horticulture Department selected Dimapur, Kohima, Mokokchung, and Wokha districts for commercial flower cultivation, based on their favorable climatic conditions, accessibility, and proximity to markets. With the adoption of high technologies, flowers are now sustainably cultivated under controlled conditions, protecting them from various damage caused by wind, heat, rain, weeds, and pests. Among the flower’s, cut flowers are the most important aspect of floriculture in Nagaland, dominating the market. The state produces high-quality flowers such as Roses, Alstroemeria, Anthuriums, Liliums, and Orchids, which are in great demand both within and outside Nagaland. Locally produced fresh cut flowers, branded as "Naga Fresh Flowers," have gained recognition both within India and in Southeast Asian countries. Although some growers have successfully exported their products to neighboring states and other regions of the country, flower production in Nagaland largely remains confined to the domestic market. This is due to the lack of cold storage facilities, absence of a grading system, insufficient market information, and poor transportation infrastructure. To promote the production of commercial flowers, foliage, and decorative plants, the Department of Horticulture organizes annual flower shows. The government also supports entrepreneurs by offering materials such as greenhouses, planting bags and pots, saplings, buy-back policy, technical assistance, cold storage facilities, etc. Additionally, research initiatives led by the Central Institute of Horticulture aim to advance the development of floriculture in the state (De and Singh, 2019). As a result, it is a significant achievement that more than 1,000 flower growers in the state have come together under the Flower Growers Society, evolving into successful entrepreneurs, putting Nagaland in the map as an emerging center of floriculture in Northeast India. Currently, six cut flowers are primarily targeted for commercial cultivation: Alstroemeria, Anthurium, Gerbera, Lilium, Orchid, and Rose. Approximately 70,000 stems of cut flowers are produced weekly in the state. Detail annual cultivation size and production of flowers in Nagaland is shown in Table-2. with their marketing and value-added products (Handbook on Horticulture, 2021).

The success of floriculture sector as one of the fastest growing sectors is mainly attributed to the large-scale participation of the women in the state. This sector is closely linked to women, as men are more engaged in the tertiary sector and other related activities, while flower cultivation is traditionally seen as a feminine pursuit (Pusa and Giribabu, 2016). Flowers have long been an integral part of Naga society, used for home decoration, and it has always been women mostly who took on the task of growing them. Floriculture is a women-friendly activity and serves as an emerging tool for women's empowerment. Women have benefited significantly from this new found opportunities in this labor market, both as smallholders and wage earners. Today, it is a source of pride that women flower growers in Nagaland are able to financially support their families through floriculture revenue. The future of the industry appears promising and could become a sunrise industry in the state, offering employment opportunity, generating revenue, and increasing income for women (Pusa and Giribabu, 2016). Therefore, this shift would enable more women to work and earn, potentially altering their gender roles and status within households. In order to promote floriculture, the government as well as flower growers took up different initiative to market the flowers such as ‘Bloom Bazar’ for women to sell flowers during weekend at a designated market place run by government. A young group of flower lovers formed an association called 'Nagaland Flower Growers Society' under the Horticulture department of Nagaland by providing trainings, seminars and organize flower shows to promote local variety and get better exposure. 'Naga Fresh' is another such creative package box meant for cut flowers for better transportation and quality. Mrs. Akruzo Pusture, a flower lover, established the 'Blossoms Florist Society' after visiting Holland's auction and breeding facilities. The society has since developed a high-tech polyhouse to cultivate export-quality flowers such as roses and liliums. A separate gallery called 'Floral Galleria' is set up during the famous Hornbill festival each year to showcase state rich flora to the visitors. Government collaborates with financial institutions like 'North East Small Finance Bank', 'Nagaland Rural Bank', and 'Bank of Baroda' to provides scheme in order to promote green-preneurs through which interested flower growers can avail loans with minimum interest rates.

Socio-Demographic Profile of Flower Growers

According to the findings of this research, in Table-2, the largest age group is between (30-40 years) which makes up 40% of the respondents. This suggests that floriculture is most popular among people in their 30s, indicating a young and vibrant business. The age group (40-50 years) also has a significant portion, making up 31.67% followed by younger participants (20-30 years) at 13.33%, while older respondents (above 50 years) have smaller respondents. Regarding occupation, homemakers with 28.33% shows that floriculture could be a supplementary or primary source of income for women at home. As many as 23.33% are involved in small businesses, which indicates entrepreneurial activity among floriculture participants. Whereas floriculture as the primary occupation accounts for 16.67%, which shows that women now considered floriculture as their main income source. The diversity in occupations highlights that floriculture is often pursued alongside other work. Nearly half of the respondents are married with 46.67%, which suggests that married individuals seek additional income sources to support family needs whereas a significant portion of 36.67% is unmarried, indicating that both single and married women are actively engaged in floriculture followed by smaller portion of 16.67% are divorced or widowed, who may rely on floriculture for financial independence or supplementary income. Studies shows 38.33% respondents have completed undergraduate education, suggesting that floriculture is seen as a viable option for educated individuals and those with a matriculation level make up 26.67%, while 13.33% have completed postgraduate studies, further indicating that floriculture attracts educated individuals (Table-2). A small percentage of 8.33% have no formal education, showing that educational background varies among flower growers and anyone can join this sector irrespective of your educational background. The majority of respondents with 56.67% come from medium-sized households which shows that floriculture may be a family-based activity followed by large households with 30%, indicating a prevalence of larger families who might use floriculture to meet economic needs. Household size distribution shows that floriculture is a family activity and may be vital for economic support, especially in medium and large households.

Table-2: Demographic Profile of Flower Growers

Age Group	No. of Respondents	No. of Respondents in (%)
20-30	8	13.33
30-40	24	40
40-50	19	31.67
50-60	7	11.67
>60	2	3.33
Primary Occupation	No. of Respondents	No. of Respondents in (%)
Floriculture	10	16.67
Govt. employed	6	10
Small business	14	23.33
Agriculture	13	21.67
Homemaker	17	28.33
Marital Status	No. of Respondents	No. of Respondents in (%)
Married	28	46.67
Unmarried	22	36.67
Divorcee/Widowed	10	16.67
Educational Level	No. of Respondents	No. of Respondents in (%)
No Formal Education	5	8.33
Primary	8	13.33
Matriculate	16	26.67
UG	23	38.33
PG	8	13.33

Contd...

Household Size	No. of Respondents	No. of Respondents in (%)
3-Jan	6	10
6-Apr	34	56.67
9-Jul	18	30
10 above	2	3.33

Source: Based on Field Survey

Women Involvement in Floriculture

Table-3, nearly half of the women florist 45% has 4-6 years of experience which suggests a steady and growing involvement in the floriculture business while 26.67% have more than 6 years of experience, indicating that a substantial portion of women have long-term experience, possibly contributing to their expertise and success in the sector. Whereas a smaller group of 20% has been involved for 1-3 years, mostly newer growers exploring the economic potential of floriculture followed by 8.33% of women who involved for less than 1 year, which may reflect the stability of the floriculture sector, with fewer new entrants compared to those with longer involvement. Overall, the studies shows that floriculture is a well-established activity for many women in Nagaland. Among types of flowers cultivation, cut flowers are the most popular type, with 76.67% of women cultivating them. Cut flowers, such as roses, alstroemeria, gerbera and lilies, are in higher demand due to their aesthetic value and marketability. Ornamental plants are cultivated by 13.33% of women, indicating a niche interest due to less economic potential in decorative gardening. While medicinal plants are grown by 10% of women which shows a certain awareness of the potential value of floriculture beyond aesthetics, tapping into the market for medicinal and herbal products. No respondents grow loose flowers as there is lack of demand for loose flower in the local market. The majority of respondents, 60%, cultivate flowers on size of land ranging from 500-1000 sq ft, indicating that floriculture is primarily practiced on small to medium-sized plots. 31.67% of respondents have larger plots, more than 1000 sq ft, which shows higher production capacity or commercial-scale floriculture (Table-3). Only 8.33% cultivate flowers on plots smaller than 500 sq ft, indicating that most women have access to more substantial plots of land for cultivation, enhancing their production capabilities. When considering for marketing, 38.33% of women choose to sell their flowers through flower shops due to their stable customer base and the potential for better profit margins, making this the most common sales platform. 31.67% of flower growers choose wholesale buyers which shows a significant portion of growers produce flowers in bulk to larger markets or regions outside of Nagaland whereas 30% choose to sell their flowers directly in local markets, reflecting a strong local demand for flowers and small-scale growers prefer direct sales for immediate income without relying on intermediaries. This analysis suggests that women in Nagaland are significantly engaged in floriculture, with diverse experience levels, land sizes, and sales channels, contributing to local economies through flower cultivation.

Table-3: Women Involvement in Floriculture

Duration of floriculture	No. of respondents	No. of respondents in (%)
Less than 1 year	5	8.33
1-3 years	12	20
4-6 years	27	45
More than 6 years	16	26.67
Type of flowers for cultivation	No. of respondents	No. of respondents in (%)
Cut flowers	46	76.67
Loose flowers	0	0
Ornamental plants	8	13.33
Medicinal plants	6	10
Size of land	No. of respondents	No. of respondents in (%)
<500 sq ft	5	8.33
500-1000 sq ft	36	60
>1000 sq ft	19	31.67
Sell flowers in	No. of respondents	No. of respondents in (%)
Local markets	18	30
Flower shop	23	38.33
Wholesale buyers	19	31.67

Source: Field Survey

Economic Benefits of Flower Growers

Traditionally, the Naga community who resides in hilly regions, has been majorly engaged in agriculture, cultivating a wide range of fruits and vegetables. People followed traditional agricultural practices such as jhum cultivation and wet-rice terrace farming. During agricultural off-seasons, the community diversifies into activities such as weaving, logging, and gathering forest produce. Many individuals initially began flower cultivation as a hobby, which gradually transformed into a source of income, highlighting its potential for growth. However, research indicates that only a small percentage of cultivators make significant investments in floriculture, primarily due to financial limitations, uncertainty, and insufficient government support for a long time. Floriculture operations remain largely small-scale and lack systematic planning. Nevertheless, despite its modest scale, floriculture has had a positive impact on household incomes, particularly in empowering women, entrepreneurs, and unemployed youth in the region. The studies show data on annual investments and incomes in floriculture, with respondents categorized by the amount of investment and income in thousands of Rupees (Rs.) shown in Table-4. For instance, 11 respondents reported annual investments of less than Rs. 10,000, while 28 respondents reported investments between Rs. 10,000 and Rs. 30,000 followed by 8 respondents and 13 respondents invested up to Rs 50000 and above Rs 50000 respectively. overall, the data suggests that women are making significant financial commitments to floriculture, with a wide distribution of investment levels, from smaller operations to larger-scale businesses. Similarly, the table presents data on annual income from floriculture. For example, 10 respondents reported annual incomes of less than Rs. 20,000, while 27 respondents reported income of Rs. 50,000 and 9 respondents have income up to 1 lakh followed by 14 respondents earning more than a lakh. Profits vary across different flower products, with significant returns from cut flowers and bouquet arrangements. Popular varieties include Alstroemeria, Lilium, Anthurium, and various dried flowers (Table-4).

Challenges of Flower Growers

Table-5 presents the challenges faced by women in floriculture. 96.67% of respondents identified the lack of storage facilities as the most critical challenge in floriculture. This near-universal concern suggests that without proper storage, the quality of flowers deteriorates quickly, leading to financial losses. The absence of cold storage or other preservation methods limits the shelf life and marketability of flowers, causing a significant bottleneck in the supply chain. While taking in-depth interview, 91.67% of respondents reported a lack of infrastructural facilities as a major hurdle like absence of essential infrastructure such as roads, water supply, greenhouses, and transportation.

Table-4: Income and Investment in Floriculture

Annual Investment in Floriculture (Rs 000)	No. of Respondents	No. of Respondents in (%)
<10	11	18.33
20-Oct	15	25
20-30	13	21.67
30-50	8	13.33
>50	13	21.67
Annual Income in Floriculture (Rs 000)	**No. of Respondents**	**No. of Respondents in (%)**
<20	10	16.67
20-50	27	45
50-100	9	15
>100	14	23.33

Source: Field Survey

The lack of infrastructure can severely hamper the ability to grow, maintain, and transport flowers efficiently, leading to reduced productivity and profitability. 86.67% of respondents cited a lack of training and support as a significant challenge. As many women involved in floriculture do not have the necessary technical knowledge or skills to optimize their operations and mostly self-taught. Training in modern floriculture techniques, pest management, and business practices is essential for improving yields and profitability, and the absence of such support system hinders their ability to broader scale. 81.67% of respondents face difficulties due to a lack of post-harvest techniques. Post-harvest processing, includes sorting, grading, packaging, and preservation, which is crucial for maintaining flower quality after harvest (Table-5). Lack of these techniques can lead to significant losses due to spoilage and damage, reducing the potential income from flower sales. 75% of respondents mentioned the lack of market facilities as a challenge. This may indicate difficulties in accessing markets where they can sell their flowers at fair prices. The absence of organized marketplaces or direct access to buyers could force women to sell their products at lower prices, reducing their overall earnings. As many as 58.33% of respondents identified the lack of government and institutional finance as a challenge. Access to affordable credit and financial support is crucial for expanding operations, investing in better technology, and improving infrastructure. The lack of such financial backing can prevent women from scaling their floriculture businesses or even maintaining them effectively.

Table-5: Challenges in the Production of Flower

Sl. No.	Challenges	Frequency	Percentage
1	Lack of storage facilities	58	96.67
2	Lack of infrastructural facilities	55	91.67
3	Lack of training n support	52	86.67
4	Lack of post-harvest techniques	49	81.67
5	Lack of market facilities	45	75
6	Lack of government & institutional finance	35	58.33

Source: Field Survey * Multiple Response

Prospects of Floriculture

Nagaland have abundant land resource available for cultivation, and is commonly own by clans, community and villages and used for commercial agriculture and shifting cultivation. It is also fortunate to have abundant water resources from rainwater, streams, and groundwater. Since water is a crucial element for plant growth, its ample availability at production sites, offers a significant advantage by reducing the need to purchase water for irrigation. The state has an ideal climate for large-scale flower cultivation, throughout the year creating opportunities for expansion. The cultivation of cut flowers under protected conditions has enabled growers to produce flowers of exceptional quality that meet international standards. With further improvements, these flowers have the potential to compete more effectively in the global market. Nagaland's proximity to international borders offers significant export potential, positioning it as a key center for south Asia flower trade. In local market, modernization and shifting societal trends are driving force of greater demand for flowers, particularly during events such as weddings, birthdays, and anniversaries, indicating the need for expanded cultivation. The floriculture industry in Nagaland has received substantial support from the State Horticulture Department, in partnership with the Ministry of Agriculture, Government of India, under the HMNEH scheme. This collaboration has greatly benefited many growers, while also attracting new entrants to the floriculture business. Growers have been provided with subsidies, including polyhouses and planting materials, training sessions, saplings, which form the foundation of the floriculture sector.

Conclusion

Women in Nagaland play a vital role in floriculture, contributing both to their household economies and to the region's overall economic development. Nagaland venture into floriculture much later than many other states of India but has grown rapidly as an important landmark for floriculture. It addresses fundamental economic and social challenges within the naga community. However, in spite of the rapid development of this sector, there are still many structural challenges left behind. Addressing these issues through targeted interventions, such as capacity building, improved infrastructure, training support, increased awareness of government schemes and enhanced financial access, will empower the flower growers further and unlocked the full potential of floriculture as a sustainable source of income and economic growth. The state has a tremendous scope for floriculture and overcoming the challenges will propel the business to grow. Research on floriculture should focus on breeding high-yielding crops, disease- and pest-resistant varieties of cut flowers. Additionally, growers must be equipped with the necessary training to implement integrated pest and nutrient management strategies, along with the promotion of farm mechanization. In conclusion, the Naga tribe's involvement in the floriculture industry highlights the transformative potential of agriculture, showcasing how the strategic use of natural resources can foster economic growth, social progress, and improved well-being. With continued support and innovation, the future promises significant opportunities for the expansion of flower cultivation in Nagaland and beyond.

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MONITORING LAND USE LAND COVER CHANGES AND IT'S IMPACT ON FOREST COVER IN GOALPARA DISTRICT, ASSAM, USING REMOTE SENSING DATA

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Abstract

Land use and land cover change (LULCC) is one of the raising global environmental issues. The present paper attempts to analyze the land use land cover and its relation to forest cover changes in Goalpara district. The dynamic changes in Land Use Land Cover and forest cover changes of Goalpara district are analyzed for the year of 1993, 2003, 2013, and 2023 in Goalpara district, with Landsat imageries with 10 years' gaps time periods. The image classification was done through maximum likelihood supervised classification schemes in GIS environment. The major outcomes of the studies was found that in the long 30 years of time interval form 1993-2023, it is clearly shown that in the classes of agricultural plantation (174.28 sq. km), barren land (153.65 sq. km), and built-up (80.37 sq. km) area have constantly increased while in the classes i.e. cropland (-243.21 sq. km), dense vegetation (-43.66sq.km), moderate vegetation (-65.37sq. km), and water bodies (-69.71sq. km) in the same the forest cover have losing their area from 500.5 sq. km(27%) in 1993 to 407.8 sq. km(22%) in 2013 while other land use shows increasing. Again, it's also found that the co-relation between Forest and Non-forested area is strong negative correlation with -0.99 value. The average overall accuracy of whole classified LULC is found 89.75% with 0.84 kappa coefficient value.

Introduction

Land use refers to human activities (features) that occur on the earth's surface. Land cover is defined as the amount of land covered by physical features or natural elements on the earth's surface. Today, land use and land cover are rapidly changing, led to a global issue. Land use and land cover change (LULCC) is regarded as

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an important technique for measuring global change at various spatio-temporal scales (Lambin, et al. 2003). The majority of land use and land cover changes have occurred as a result of human activity in the past or recently. The rapid rise of the population growth is taken as detrimental factors of a cause land use and cover change any place(Rahaman, S et al. 2020). LULCC is an important component to understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes, land use and land cover change study are very essential for the determining the current and future scenario for the managing our natural resources and environment problem (Khan, R & D.C. Jhariya, 2016). Population growth has been found negative effect on land use/land cover of the area. Nowadays, land LULCC is an important subject to study in order to have a better understanding of natural disasters, environmental protection, land management, and planning. Again, Urbanization is one of the primary variables that has significantly influenced the LULCC in the world (Fichera, C.R. et al.2011; Abebe Gebeyehu et al. 2021; Kuldeep et al. 2011; Narzary, Sankar Gauri 2013; and T.S. Rawat and Manish Kumar 2015). Many researchers have studied globally on LULCC using remote sensing and GIS; T.S. Rawat and Manish Kumar, 2015; Kayet, Pathak & Narayan et al. 2015; Yousif Elnour Yagoub, et al. 2017; Rahman Syafiqa Haidar Afif Abdul, et al. 2022), where most the scholar's suggested that forest cover, Agriculture land and water-bodies (Pattanayak & Diwaka, 2016) had been found decreased, while fallow or barren land, built-up land increased day by day.

Whereas, GIS and remote sensing techniques are regarded as an effective method of prediction, monitoring, and analysis of LULCC dynamic changes. So many researchers had conducted studied on LULCC (Wang, Munkhnasan et al. 2021; Chetry and Hazarika, 2020; Das and Pandey 2021; Bufebo, B, & Elias, E., 2021)) based on geospatial techniques. Because remote sensing data provide spatio-temporal datasets, thorough changes of landscape easily detect. The majority of the findings revealed that built-up areas, wasteland, and natural forest cover are increasing while grassland and wetlands are losing land. Malini P.J & Koppad G. Arjun, 2021, had also found same outcomes, where have more anthropogenic activity, such as settlements, roads, and industrial areas. While, cultivated land, drainage, and lakes have all declined significantly, while industrial areas have expanded. Globally, declining forest area and deforestation led to status and changes of forest cover, which have been noticed during in the last thirty years, and becomes a global issue. The changes in LULCC of any region have directly impact on forest cover area (Narzary Sankar Gauri, 2013). But in case of present study area (Goalpara district), since till that the adequate study using geospatial techniques have not been found, where land use land cover is very dynamics. The presents study area is cover with huge natural resources, including forest, water, soils, minerals as well as natural ecological values. The population growth in the study area causing pressures on forest ecosystems which led to such a problems like human-elephant conflict, encroachment of forest area, unplanned development etc. Therefore, management of these resources requires an effective measurement of which only know LULCC studies.

Study Region

Goalpara district is located in the western part of Assam and covers a geographical area of 1824 square kilometres. It is located between 25053' - 26030' north latitude and 9007' - 9105' east longitude. The district is bounded by Kamrup district in the eastern part, Dhubri and Bongaigoan district in the Western part and Garo hills and Brahmaputra plain in the south and north respectively. The study region is rich in natural resources, with the majority of the land covered in forest. In the district, there are found about 700 species of angiospermic plants in the district of which 427 species belong to a dicotyledonous group (Deka, Sangeta et al. 2019). In the district, there are 55 RF and 48 PRF (Medhi and Kar, 2016) and a lot of unclassed forests are found. Where, the most valuable moist deciduous trees like Sal, Teak, Gamari, Bamboos, and Simul, etc. are abundantly found in the district. However, changes in LULC have an impact on cover forest cover in the research region, such as highway expansion and increasing population, therefore studying land use/land cover is necessary to understand the actual change of landscape. This work contributes to understanding the dynamic change of LULC concerning forest cover.

Objectives

(1) To highlight the dynamic changes of LULC changes in Goalpara District since 1993-2023 with a 10 years' time interval,
(2) To assess the periodic forest cover change and its relation LULCC in the study area.

Database and Methodology

The Landsat series imageries were collected from United State Geological Survey (https://earthexplorer.usgs.gov/), for the 1993(landsat5MSS), 2003 (Landsat7 ETM+), 2013 (Landsat 8 OLI), and (Landsat 8/9 OLI/TIR) with 30 m spatial resolution. For visualization and Classification of LULC and forest cover Visible wavelength (i.e., Blue, Green, and Red), and Near-infrared length were used, due to their reflectance helping to recognize the earth's surface features. The summary of satellite data is shown in Table-1.

Table-1: Details of Used Satellite Imageries

Satellite	Sensor	Spatial Resolution	Date of Acquisition	Total Bands
Landsat 5	MSS	30 m	04-03-1993	7
Landsat 7	ETM+	30 m	19-01-2003	8
Landsat 8	OLI	30 m	08-12-2013	11
Landsat 8/9	OLI/TIRS	30 m	10-01-2023	11

Source: NRSC, Hyderabad

Pre-Processing and Classification

The satellite images were pre-processed in Erdas Imagine (Version-2015) software to increase visualization and image quality (Ashwini, & Sil, 2022). The Band composite (layer stacking) and atmospheric adjustment for quality enhancement were done, followed by subset, the study area of the image. The LULC classes were classified using the supervised classification method (maximum likelihood) in Arc GIS (version 10.3) software, with a total of nine classes which shown in the Table-2. The forest covers has been classified in to three categories namely dense forest, moderate forest, and sparse forest. Further retrieved from supervised classed images to correlate with transitional changes in the forest category. Accuracy assessment has been done for validation of classified images, through confusion matrices. (Rahman Syafiqa Haidar Afif Abdul, et al. 2022). The Google Earth Pro application had been used for verification of classified results with 500 samples, taken for each identified image to validate the results. Based on these samples, the following accuracy assessments were made. The following accuracy methods has been used. User accuracy is defined as the probability that a pixel classified on the image represents that category on the ground. The figures in row reliability (user accuracy) show the dependability of classes in the categorized image.

$$\text{User Accuracy}\left(\text{UA}\right)=\frac{\begin{array}{c}\text{Number of Correctly Classified}\\ \text{Pixels in each Category}\end{array}}{\begin{array}{c}\text{Total Number of Reference Pixels}\\ \text{in that Category}\left(\text{The Row Total}\right)\end{array}}\times 100 \quad (1)$$

Total number of correct pixels in a category/ Total number of pixels of that category derived from the reference data (i.e., column total). The producer's accuracy is defined as the likelihood that any pixel in that category was properly classified. The values in column accuracy (producer's accuracy) represent the accuracies of the categories in the classification image.

$$\text{Producer Accuracy}\left(\text{PA}\right)=\frac{\begin{array}{c}\text{Number of Correctly Classified}\\ \text{Pixels in each Category}\end{array}}{\begin{array}{c}\text{Total Number of Reference Pixels}\\ \text{in that Category}\left(\text{The Column Total}\right)\end{array}}\times 100 \quad (2)$$

Total number of correct pixels in a category/ Total number of pixels of that category derived from the reference data (i.e., row total)

Omission Accuracy (OA)

Off-diagonal row elements reflect ground truth pixels from a specific class that were removed from that class during classification. Such errors are frequently referred to as errors of omission or exclusion.

Commission Accuracy (CA)

The off-diagonal column elements indicate ground truth pixels from various classes that were included in a specific categorization class. Such errors are sometimes referred to as errors of commission or inclusion.

Overall Accuracy (OA)

It is also desired to compute an accuracy metric for the entire image across all classes represented in the classed image. The total accuracy of the map for all classes can be expressed by calculating the fraction of pixels properly classified which given in the Equation (3).

$$\text{Overall Accuracy}\left(\text{OA}\right)=\frac{\begin{array}{c}\text{Total Number of Correctly}\\ \text{Classified Pixels (Diagonal)}\end{array}}{\begin{array}{c}\text{Total Number of}\\ \text{Reference Pixels}\end{array}}\times 100 \quad (3)$$

Kappa Coefficient (k)

Kappa coefficient is a multivariate measure of agreement between rows and columns in an error matrix (Khan et. al 2016). The formula for computing kappa statics is as follows equation 4:

$$\text{Kappa Coefficient }(k) = \frac{(\text{TSxTCS}) - \sum(\text{Column Total x Row Total})}{(\text{TS2} - \sum(\text{Column Total} - \text{Row Total})} \times 100 \qquad (4)$$

Here, TS- Total No's of Sample, TCS-Total no's of correctly classified pixels

Result and Discussion

Periodical Changes of LULC Changes

(a) Landuse and Landcover (1993-2003)

During this time periods the positive changes (increase) have been observed in the classes of Agricultural plantation (125.11 sq. km), barren land (33.79sq. km), built-up area (60.08sq.km), sandbar (37.60 sq. km), on other hands the negative changes or area declined in the classes of Cropland (-106.91sq. km), Moderate Vegetation (-98.24 sq. km), Water-bodies (-29.36 sq. km) Dense Vegetation (-21.63sq. km) Sparse Vegetation (-0.44 sq. km). This is determined that forest cover area have losing their area converting into various human land use. Meanwhile, the increasing agricultural plantation area simply means the forest area has been occupied by various plantation agriculture activities i.e., expansion of rubber plantation, tea cultivation, and various crops cultivation in the heart of forest land (Fig. 1).

(b) Landuse and Landcover 2003-2013

Again, in this time interval, the changes detected in the classes of barren land have increase with an area of 93.43 sq. km, the built-up area increased 63.06 sq. km, sparse vegetation, 64.52 sq. km. where the major decline have observed in classes of agricultural plantation -95.78 sq. km, cropland -79.99 sq. km and sandbar -46.59 sq. km. the constant increase of built-up area indicated the other land use cover changes such as cropland, dense vegetation.

(c) Landuse and Landcover 2013-2023

During 2013-2023, the dramatically changes of LULC has been observed in the classes of agricultural plantation (144.95sq. km), barren land (26.42 sq. km), and moderate forest 21 sq. km), in the same area losses in the periods shown in the classes of cropland (-56.32 sq. km), built-up area (-42.77sq. km), sparse vegetation (-47.82 sq. km), and dense vegetation (-16.89sq. km) (Table-2). Here, the slightly dense vegetation and sparse vegetation have losses their area where it is transitioning into moderate vegetation and agricultural plantation classes.

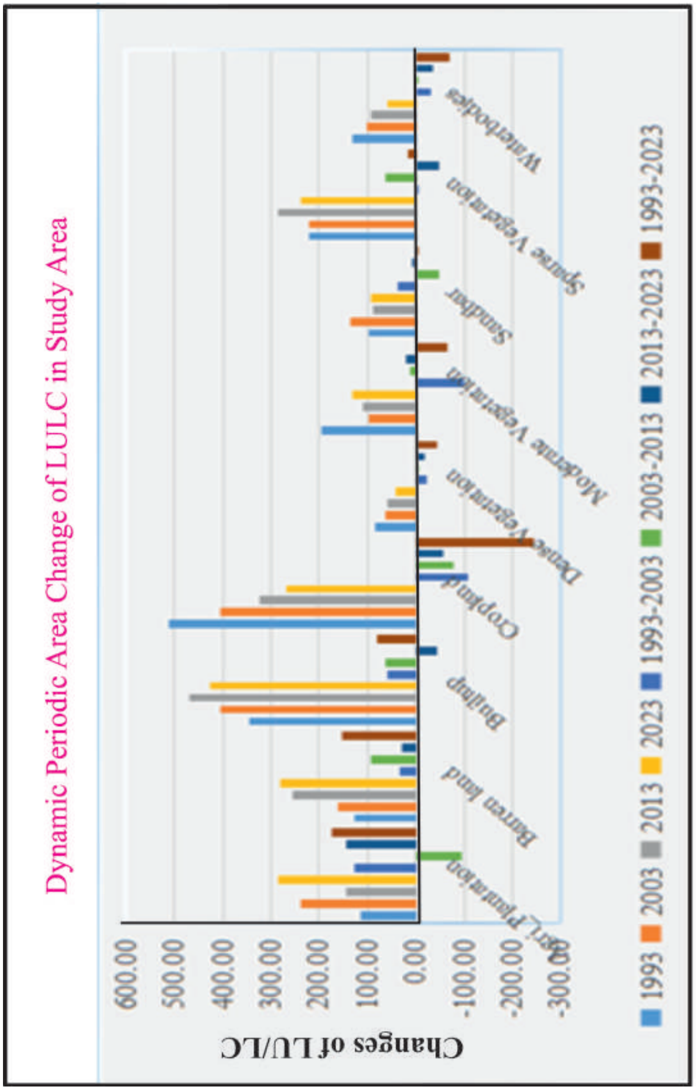
Dynamic Periodic Area Change of LULC in Study Area
Changes of LU/LC
600.00
500.00
400.00
300.00
200.00
100.00
0.00
-100.00
-200.00
-300.00
Barren land
Builtup
Cropland
Dense Vegetation
Moderate Vegetation
Sandbar
Sparse Vegetation
Waterbodies
1993
2003
2013
2023
1993-2003
2003-2013
2013-2023
1993-2023

Fig. 1

Table-2: LULC Categories-wise Area and its Net Changes Year-wise

LULC Classes	LULC Changes Area (in sq. km)				Net Area Change (in sq. km)			
	1993	2003	2013	2023	1993-2003	2003-2013	2013-2023	1993-2023
Agri._Plantation	112.62	237.72	141.94	286.89	125.11	-95.78	144.95	174.28
Barren land	126.67	160.46	253.90	280.32	33.79	93.43	26.42	153.65
Built-up	346.01	406.09	469.15	426.38	60.08	63.06	-42.77	80.37
Cropland	512.39	405.48	325.50	269.18	-106.91	-79.99	-56.32	-243.21
Dense Vegetation	83.69	62.05	56.92	40.03	-21.63	-5.13	-16.89	-43.66
Moderate Vegetation	194.62	96.39	108.25	129.25	-98.24	11.86	21.00	-65.37
Sandbar	96.32	133.92	87.33	93.69	37.60	-46.59	6.36	-2.62
Sparse Vegetation	222.20	221.77	286.29	238.47	-0.44	64.52	-47.82	16.27
Water-bodies	129.39	100.03	94.64	59.69	-29.36	-5.40	-34.95	-69.71

Source: Authors

Again, the barren land area has been decreased in terms of its area which means the cropland is converted into wasteland or barren land (Fig. 2).

(d) Landuse and Landcover (1993-2023)

In the long 30 years of time interval, it is clearly observed that in the classes of agricultural plantation (174.28 sq. km), barren land (153.65 sq. km), and built-up (80.37 sq. km) area have constantly increased while in the classes i.e., cropland (-243.21 sq. km), dense vegetation (-43.66sq.km), moderate vegetation (-65.37sq. km), and water bodies (-69.71sq. km) have losing and to converted into other landuse classes (Fig. 2 and Table-3).

Accuracy Assessment

The Accuracy assessment usually done by post-classification for validation of classified image. In Table-3 depicts the whole accuracy table of four different time periods (i.e., 1993, 2003, 2013, and 2023). Based on UA, PA, OA, and CA accuracy the overall accuracy and kappa coefficient have been calculated. The overall accuracy and Kappa coefficient was found 88.4%, 0.84 in 1993, 95%, 0.84 in 2003, 88.4%, 0.85, in 2013 and it is 88.4%, 0.84 in 2023 respectively. The highest overall accuracy was found 95% in the year 2013and maximum value of Kappa value found 0.85in the 2023. The average overall accuracy of whole classified LULC is found 89.75%.

LULC Changes and its Relation to Forest Cover Changes in Goalpara District

The forest is an important part of our natural land cover in the earth surface. There is an active relationship in changing forest cover and LULC changes. In the study area, forest cover has been categorized in to three type namely dense forest, moderate forest, and sparse vegetation. From the classification, it’s detected that during the periods of 1993-2003 the category wise lose forest area where, moderate forest -98.2(-5.4%) and dense forest -21 sq.km (-1.2%), and total net change have found -120.3 sq. km (-6.6%).

Where during the period of 2003-2013, the dense forests have loss an area of -5.1 sq.km (-0.3%), and sparse forest gain an area of 64.5 sq. km (0.7%), and the net change area was 71.3sq.km (3.9%). In the periods of 2013-2023, the highest forest cover change have detected at - 47.8 sq. km (2.6%), and dense forests have loss an area of - 16.9 (-0.9%), while moderate forests gained 21sq.km (1.2%). Where annual change has detected -43.7 sq. km (-2.4%). In the 1993-2023 period time -43.7 sq.km (-2.4%), moderate forest have loss-65.4 sq.km(-3.6%),

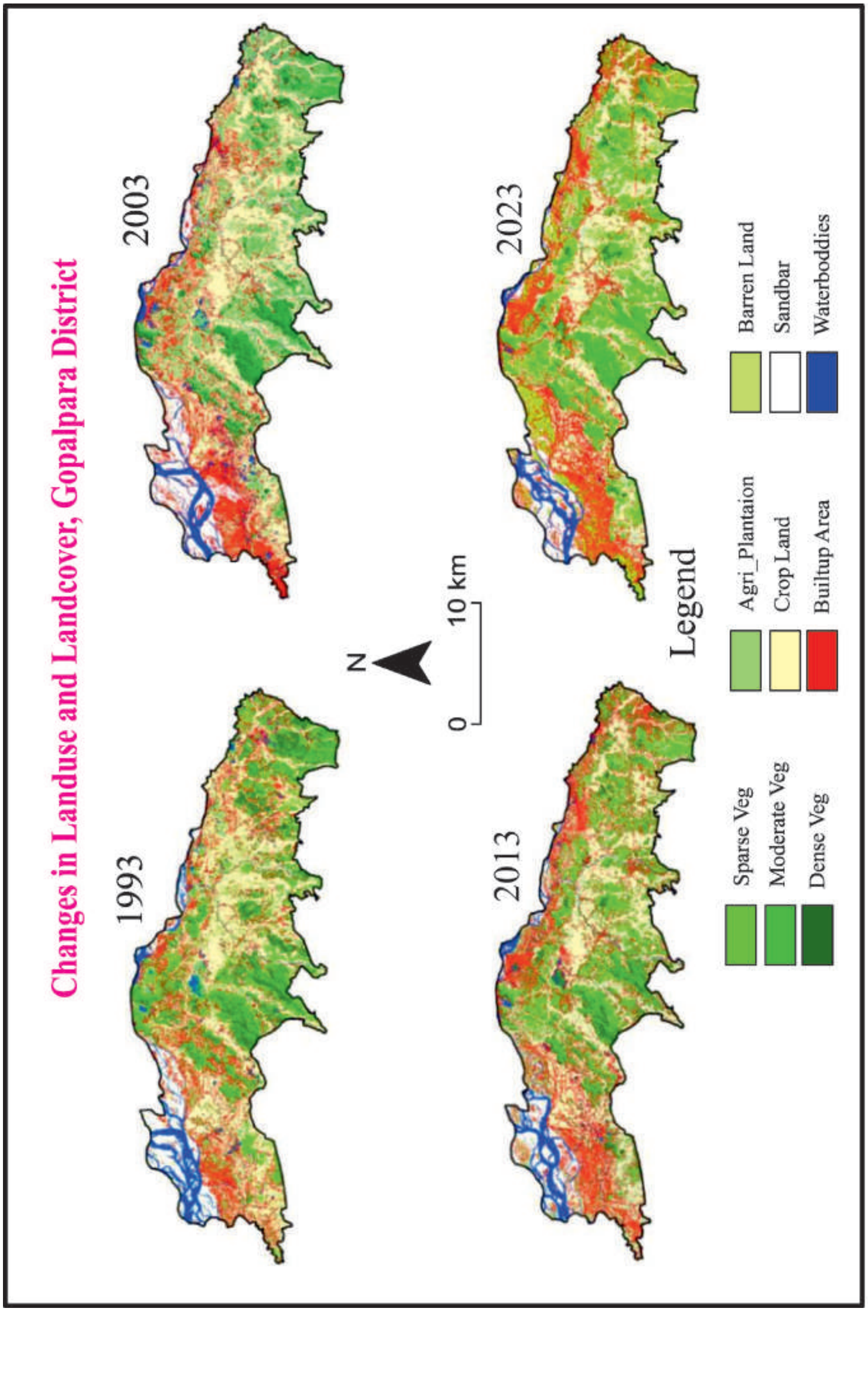
Changes in Landuse and Landcover, Gopalpara District
1993
2003
2013
2023
N
0
10 km
Legend
Sparse Veg
Moderate Veg
Dense Veg
Agri_Plantaion
Crop Land
Builtup Area
Barren Land
Sandbar
Waterboddies

Fig. 2

Table-3: Accuracy Assessment Calculation of Classified LULC Map of the Study Area

LULC CLASS	1993				2003				2013				2023			
	UA%	PA%	OA%	CA%	UA%	PA%	OA%	CA%	UA%	PA%	OA%	CA%	UA%	PA%	OA%	CA%
Cropland	96.4	91.6	3.54	3.66	82.5	77.27	18.7	17.4	90.6	95.7	4.23	8	93.3	89.7	10.26	7.14
Barren land	91.7	97.8	8.25	8.98	93.3	83.3	6.67	6.67	79.3	92	8	20.6	80	48	52	20
Built-up	87.2	95.7	12.75	14.6	90.4	100	0	2.21	88.6	92.8	7.14	11.36	95.9	95.1	4.88	4.1
Sandbar	95.6	81.48	4.35	4.54	79.0	40	20.9	20.9	100	95.6	4.35	0	65	83.8	16.13	35
Agri_Plantation	62.5	29.4	37.5	60	62.5	87.5	33.3	37.5	83.3	33.3	66.6	16.6	80.8	100	0	19.1
Dense veg.	75	42.86	25	33.3	84.8	66.6	9.46	15.1	68	94.4	2.4	32	95.4	70	30	4.55
Moderate Veg.	66.6	66.6	33.33	50	90.7	87.5	14.2	9.3	100	97.6	4.35	0	85.71	96	4	14.2
Sparse Veg.	58.6	77.27	41.38	70.5	94.8	81.25	11.2	5.17	95.6	95.6	4.35	4.35	81.2	81.2	18.	18.75
Waterbodies	80	50	20	25	75	75	76.9	25	75	62.5	37.5	25	90.9	71.4	28.5	9.09
Overall Accuracy	88.4				87.2				95				88.4			
Kappa Statistics	0.84				0.84				0.84				0.85			

Source: Authors

Table-4: Forests Area and Non-forested Area of Goalpara District

Category	Forest Area (in sq. km.)								Net area Change (in sq. km)							
	1993	%	2003	%	2013	%	2023	%	1993-2003	%	2003-2013	%	2013-2023	%	1993-2023	%
Dense Veg.	83.7	4.6	62.1	3.4	56.9	3.1	40.0	2.2	-21.6	-1.2	-5.1	-0.3	-16.9	-0.9	-43.7	-2.4
Moderate Veg.	194.6	10.7	96.4	5.3	108.2	5.9	129.3	7.1	-98.2	-5.4	11.9	0.7	21.0	1.2	-65.4	-3.6
Sparse Veg.	222.2	12.2	221.8	12.2	286.3	15.7	238.5	13.1	-0.4	0.0	64.5	3.5	-47.8	-2.6	16.3	0.9
Total forest Area	500.5	27.4	380.2	20.8	451.5	24.8	407.8	22.4	-120.3	-6.6	71.3	3.9	-43.7	-2.4	-92.8	-5.1
Non Forest area change	1323.5	72.6	1443.8	79.2	1372.5	75.2	1416.2	77.6	120.3	6.6	-71.3	-3.9	43.7	2.4	92.8	5.1
Total Area	1824	100	1824	100	1824	100	1824	100	120.3	-6.6	-71.3	3.9	43.7	-2.4	92.8	-5.1

Source: Authors

while sparse forest have gain an area 16.3 sq.km (0.9%) and annual forest loss is found -92.8 sq. km (5.1%) in the periods of 1993-2023. Again the 'r' value for correlation between Forest cover area and non- forest cover area has shown strong negative correlation with -0.99 value. This changing pattern has been observed because of decreasing trend of area coverage of the forest area day by day with increasing changing pattern of other uses of land.

Conclusion

Land use and land cover has become crucial basis work to carry for analysis of dynamic change of land use, prevention to natural disaster, environmental protection, land management and planning, etc. land use, and land cover have become essential foundational studies. This research describes that physical and cultural factors have changed the land cover and land use Goalpara district. The area covered by forests has undergone considerable changes, which are indicative of the rate of population growth and other land use pressure on forest land. The findings unequivocally demonstrate how land usage has changed throughout time and space and how its impact on forest cover area changes in the study area. This research illustrates the changes over the past 30 years using remote sensing and GIS techniques. A significant increase in built-up areas, barren land, and agricultural plantation was linked to the simultaneous disappearance of land cover categories such as water bodies and dense forest moderate forest as well as cropland. Whereas the study reveals that LULC pattern changes have a direct effect on forest cover area. Where forest areas shown decline due to other human other land use have been increasing. The LULC change detection study helps in the planning and management of geographical areas. This study illustrates the changes due to human activities, which gradually change dense forest areas into sparse forests, agricultural areas, and built-up areas. Therefore, it can be concluded that a significant shift in land use and land cover (LULC) has occurred in the study region during the past 30 years, with growing urbanization and industrial activity serving as the primary catalysts and expansion of agricultural land.

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SOCIO-ECONOMIC STATUS OF SCHEDULED CASTES: A CASE STUDY OF GOLA BLOCK IN GORAKHPUR DISTRICT, UTTAR PRADESH

Harsh Raj Yadav and Professor Shivakant Singh

Abstract

The scheduled caste population is a community based on social and economic activities, more or less; this situation remained the same even after the country got independence. The scheduled caste population has been a victim of socio-economic deprivation from many years, and they have struggled a lot to get their rights. The current study examines the socio-economic status of the scheduled caste population in the Gola block of Gorakhpur district. Socio-economic status of the different villages of the scheduled caste population were identified using the Socio-Economic Index which was formulated by the composition of various socio-economic factors like health, education, housing conditions, demographic characteristics, income-expenditure ratio, land holdings, etc. Variables of all these socio-economic factors and their values are pre-assumed and the value of Standard Socio-Economic Index (SEI) has been calculated on the basis of standard values of all above mentioned variables. Based on the value of the Socio-Economic Index, a comparative study of the socio-economic status of the Rajauli Bujurg and Surdapar Raja villages of Gola block, Gorakhpur district is analyzed in this research paper.

Introduction

The social stratification in India is significantly influenced by the caste system. Although other cultures also have a form of caste structure, it is deeply ingrained in the belief systems of Hindu societies. The caste hierarchy was traditionally divided into four Varnas: Brahmins, Kshatriyas, Vaishyas, and Shudras. The Shudras were considered as the marginalized sections of society and over time, they came to be known by various terms such as Dalits, exterior castes etc. The term "Scheduled Caste" was initially introduced by the Simon Commission and later incorporated

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into the Government of India Act, 1935, which was passed by the British Parliament. This act defined Scheduled Castes as such castes, races or tribes or parts of or groups within castes, races, or tribes being castes, races, tribes, parts or groups which were formerly known as the "depressed classes". Socio-economic development is a process of structural changes with the passage of time within a region, changes that are result of actions of subjects taken within social and economic practices. These changes influence quality of life standards in the following fields: Physical conditions i.e. possibility to satisfy needs that are associated with consumption of goods and services; it is related with the phenomena of economic growth also, socio-economic structure and entrepreneurship, access to public services which results in changes of education level, way of taking care of health etc., relation within social system , means integration between individuals, trust, security, social conflicts, environment condition and life fulfillment. Its goal is to maintain the people's physical and spiritual well-being in order to achieve the optimum level of human development in the region. Development, in the socio-economic context, refers to the improvement in standard of living through better employment, income sources, skills and opportunities of choice. Thus, socio-economic development is the process by which a society develops socially and economically both. Health care facilities, sanitization, availability of clean drinking water, high literacy level, good income-to-expenditure ratio, and land ownership are some indicators used to measure the socio-economic status of any community. Socio-economic status of any person or group is a combined social and economic measure of their position based on their health, education, and occupation status. Socio-economic status consistently and accurately predicts a wide range of outcomes throughout the individual's life. A community is a social group that shares common things like area, traditions, beliefs, values, and identity. Communities may share a sense of place in a specific geographic area (like a country, hamlet, town, or neighborhood) or virtual space through many communication platforms.

The Scheduled Castes have long been subjected to socio-economic exploitation and have been pushed into low-income occupations, less favorable trades, unsanitary environments, and degrading menial jobs. While untouchability practices may be on the decline in many areas, caste-based restrictions still confine many scheduled caste workers to undignified occupations, putting them at a disadvantage compared to other communities. The forces of urbanization, social and protective laws, affirmative action, and other government measures will gradually improve occupational mobility and living standards over time, but the majority of scheduled castes continue to face socio-economic backwardness in their living conditions.

Study Region

Gorakhpur district is located in the middle of north-east in the Gangetic plain. The Gorakhpur district is located between 26°12'N to 27°6'N latitude. It stretches from 83°04'E to 83°40'E, which is in the eastern part of the plain of Sarayupar. The area of the district is 3,321 km², which is approximately 1.38% of the territory of Uttar Pradesh. The district stretches 105 kilometers from east to west and 158 km from north to south. The district encompasses the state's north-eastern corner as well as a significant portion of the southern boundary line is parallel to the northern bank of the Ghaghara River. The boundary runs beside Sank Kabir Nagar on the west and borders Deoria on the south and east.

The district of Mahrajganj is located in the north whereas Azamgarh and Mau are situated in the south of the region. Gorakhpur is the north-eastern district of Uttar Pradesh having population of 44.41 lakh that is 2.22 percent of the state's population. District is made up with 7 tehsils i.e., Gorakhpur Sadar, Sahjanwa, Chauri chaura, Bansgaon, Khajni, Gola and Compeirganj and 19 blocks i.e., Jungle Kaudia, Chargawa, Bhathat, Pipraich, Sardar Nagar, Khorabar, Pali, Sahjanwa, Piprauli, Brahmpur, Kaudiram, Bansgaon, Uruwa, Gagaha, Khajni, Belghat, Gola, Barhalganj and Compeirganj consisting of 3448 revenue villages in which 382 of them are uninhabited. The district is made up of 14 towns and three forest areas, including one municipality i.e., Gorakhpur, seven nagar palikas viz. Pipiganj, Sahjanwa, Pipraich, Mundera Bazar, Bansgaon, Gola Bazaar and Barhalganj and six census towns viz. Air force area, Bargo, Harswakpur No. 2, Jangle Hakeem No. 2, Lahsari, and Piprauli Buzurg. At the intersection of the Rapti and Rohin rivers the district's headquarter is situated. The average elevation of district is 81.42 meters above sea level. The population growth of Gorakhpur district is lower than the state's population growth rate in the decade of 2001-11. Gorakhpur lags behind from some districts of Uttar Pradesh in the terms of social wellbeing and social development indicators such as literacy rate, per capita income, infant mortality rate, electrification of villages, teacher-pupil ratio in government primary and secondary schools, birth rate, death rate, medical facilities per capita energy consumption etc. The caste system is very dominating in the district due to this the social infrastructure cannot compete with other developed districts. The sex ratio of state is skewed towards male; it was reported 950 females per thousand males. Recent and competitive research analysis has shown that economic, cultural and social makeup of the state is the factors which are responsible for its backwardness.

Objectives

(1) To point out major social and economic variables to assess the status of the scheduled castes in the study region.

(2) To analyze the socio-economic status of the scheduled caste population in the Gola block of Gorakhpur district with the help of the Socio-Economic Index (SEI).

Data Sources and Methodology

The current study is based on quantitative and qualitative data analysis where the data is collected primarily from primary data sources i.e. questionnaires, interview schedules, focused group discussions and observation methods. This study adopted Stratified Random Sampling for the selection of the respondents. Gola block was selected because out of its total population; approximately one-third population consists of scheduled caste which is highest in percentage among all blocks of Gorakhpur. Four villages were selected for the study and the sample size was 10 per cent of the total population of the village for questionnaire and interview. This study analyzed 10 per cent respondents out of total household from each village and selected purposively 15 respondents out of 143 households of Rajauli Bujurg village and 15 respondents out of 151 households from Surdapar Raja village of block Gola. After collecting the data, the socio-economic status of the scheduled caste population in Gola block of Gorakhpur district analyzed through the socio-economic index. For this, this study used the method of calculating the Socio-Economic Index (SEI) consisting Health, Demographic and Educational Index for Social Index and Economic index separately.

Results and Discussions

Determining the Standard Socio-economic Index (SSEI)

For a comparative analysis a standard value of SEI should be determined so that the SEI value of each village can be compared to the ideal value. SSEI also sets a critical point so that the area of improvement of the village can be improved to get a good socio-economic status in the study region. For example, regarding education variable, there are various levels of education but the scholar assumed Intermediate level education as standard value and then calculated the SSEI of all the variables like this. By putting the standard values in the place of respondent’s value, the SSEI is calculated with the help of following formula:

$$SSEI = \frac{1}{2}\left\{\frac{1}{3}\left(Health\ Index + Demographic\ Index + Educational\ Index\right)\right\}$$
$$+\frac{1}{2}\left(Economic\ Index\right)$$

$$SSEI = \frac{1}{2}\left\{\frac{1}{3}\left(1+0.50+0.666\right)\right\}+\frac{1}{2}\left(0.70\right)$$

$$SSEI = \frac{1}{2}\left\{0.722\right\}+0.350$$

$$SSEI = 0.361+0.350 = 0.711$$

Table-1: Socio-economic Index of Rajauli Bujurg Village of Gola Block, 2024

Sl. No.	Social Indices			Social Index of Respondent	Economic Index of Respondent	SEI of Respondent
	Health Index	Demographic Index	Educational Index			
1.	0.625	1.00	0.666	0.764	0.60	0.682
2.	0.625	0.625	0.444	0.565	0.60	0.583
3.	1.00	0.500	1.00	0.833	0.70	0.767
4.	0.875	0.375	0.666	0.639	0.50	0.571
5.	0.875	1.00	0.833	0.903	0.80	0.852
6.	0.875	0.625	0.666	0.722	0.80	0.761
7.	0.375	0.375	0.444	0.398	0.50	0.449
8.	1.00	1.00	0.833	0.944	0.80	0.872
9.	0.500	1.00	0.666	0.722	0.40	0.561
10.	0.875	0.375	0.833	0.694	0.80	0.747
11.	0.625	0.375	0.666	0.777	0.70	0.739
12.	0.625	1.00	0.833	0.819	0.80	0.811
13.	1.00	0.625	0.944	0.856	0.70	0.778
14.	1.00	0.375	0.833	0.736	0.90	0.818
15.	0.500	1.00	0.444	0.648	0.80	0.724
	Mean SEI= 0.714					

Source: Computed by Authors

With the help of the formula of Socio-Economic Index (SEI), the index of various variables of the respondents of the Rajauli Bujurg and Surdapar Raja villages of Gola Block of Gorakhpur district are calculated (Table-2).

Table-2: Socio-economic Index of Surdapar Raja Village of Gola block, 2024

Sl. No.	Social Indices			Social Index of Respondent	Economic Index of Respondent	SEI of Respondent
	Health Index	Demographic Index	Educational Index			
1.	0.250	1.00	0.444	0.565	0.40	0.965
2.	0.875	0.375	0.666	0.639	0.50	0.571
3.	0.625	0.375	0.833	0.611	0.70	0.656
4.	1.00	0.625	0.666	0.764	0.90	0.832
5.	0.500	0.625	0.444	0.523	0.60	0.562
6.	1.00	0.500	0.833	0.778	0.70	0.739
7.	1.00	0.500	0.666	0.722	0.70	0.711
8.	0.875	1.00	0.666	0.847	0.80	0.824
9.	0.625	0.625	0.833	0.694	0.60	0.647
10.	1.00	1.00	0.444	0.815	0.80	0.708
11.	1.00	1.00	0.833	0.944	0.90	0.922
12.	0.875	0.375	0.944	0.731	0.80	0.766
13.	0.875	0.375	0.666	0.639	0.60	0.621
14.	0.875	1.00	0.444	0.773	0.70	0.737
15.	0.250	1.00	0.277	0.509	0.40	0.455
	Mean SEI= 0.714					

Source: Computed by Authors

Conclusion

The comparative analysis of socio-economic status of four villages of Gola block, Uttar Pradesh shows some interesting facts about the socio-economic status and the way of change in recent decades. The status of Rajauli Bujurg is in good condition as about two-third respondents fall above the mean and standard socio-economic status which clearly shows that the development of social and economic variables is well distributed while some of the respondents are below the mean and standard value; these respondents are mainly consist of farmers and daily wage labor which do not have access to all resources which is required to uplift the status in the society. The status of the respondents of Surdapar Raja village is also in good condition where about half of the population is above the mean and standard socio-economic condition the reason being is the educational and health facilities are in good condition as the villages are under the influence of urban centers. This study suggests that various policies and programs are formed to uplift the status of scheduled castes but due to lack of education, poor economic conditions or sometimes corruption the actual beneficiary remain deprived of the fruit of development. Hence there is a pressing need to strengthen the educational and economic infrastructure to further develop the socio-economic status of scheduled castes.

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GEOGRAPHICAL ANALYSIS OF SERVICE CENTRES IN KULLU DISTRICT, HIMACHAL PRADESH

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Abstract

This research paper embarks on a meticulous exploration of the geographical distribution and intrinsic characteristics of service centers situated within the Kullu District of Himachal Pradesh. Employing a comprehensive analytical framework, the study systematically identifies, evaluates, and categorizes these service centers, emphasizing their centrality and hierarchical organization within the broader regional context. Utilizing Geographic Information Systems (GIS) and advanced spatial analysis techniques, this research elucidates the spatial patterns and accessibility of service centers, thereby illuminating their roles and functions within the Kullu District. The researcher identified 172 service centers through comprehensive primary survey in the study area. These centers are categorized into two types based on their location and functions: urban service centers and rural service centers. This study helps to better understand how services are organized in Kullu District, providing important insights for regional planning, development, and resource management. The paper includes detailed information about each identified service center, such as their geographical coordinates, altitude, population, number of households, number of functions, centrality and hierarchy. This analysis enhances our understanding of how service centers are distributed and ranked in Kullu District, supporting improved planning and resource allocation for rural development and service delivery.

Introduction

The concept of development poles has long been a central focus in the field of regional economics and development planning. The underlying premise is that economic growth does not occur uniformly across a region, but rather starts as "points or development poles" with varying intensities, and then spreads through different channels, ultimately affecting the entire economy (Johansson et al., 2001). Service centres, also known as central places, hold a crucial role in the field of regional development and planning, as they serve as hubs for the distribution of goods, services, and information within a given region. These centers, whether they be large cities or smaller towns, are intrinsically linked to the surrounding areas and play a vital role in shaping the economic and social fabric of a region. The geographic principles underlying the study of cities and service centers emphasize the importance of their spatial relationships and connections to the broader landscape (Ridgley, 1925). Any permanent settlements who's having some functions for fulfill the socio and economic demands of nearby areas may be known as a Service Centre. The population, existing infrastructure facilities, distance and movement of the people have been used to identify the service center and complementary area. The studies regarding service centre were done by many scholars like Hagerstrand (1952), Berry (1967) and Sen et al. (1971). Service centers are local units through which relatively higher services and facilities are provided mainly to the people of a certain area. These service centers are located at a convenient central location in their specific area and are connected to it by transport routes. These service centers actually act as centers of attraction for the dependent border areas spread around them. These border areas are actually rural areas and these service centers are primarily born to serve this rural border area. Therefore, these centers are also called rural service centres. They appear as urban islands on rural land and are always ready to provide facilities to their neighboring areas and in return receive many primary products for the consumption of their residents and for sending to other distant places. How far a service center provides its services within its border area. It depends on its size and functional level. If the service center is small, it has less facilities, hence its area of influence is also less. Due to which he depends on high level service centers to get high level facilities. Thus, a hierarchy is found in these service centres. These service centers provide services like retail and wholesale, education, health, administrative, marketing, communication, financial etc. (S.C. Bansal, 2013.14) These service centers are in the form of gathering centres, because they act as a transition or intermediate position between city and village. (Galpin, 1915) Service centers are attractive points in the rural community that provide a variety of functions and services. By identifying them, information can be obtained about the distribution of services and facilities in an area. Through this distribution, those areas can be clearly marked which are more or less developed in terms of facilities, thus, this study encourages coordinated regional planning.

Objectives

(1) To identify the service centres in study area.
(2) To study the centrality and hierarchy of service centres in the study area.

Study Region

Kullu district is one of the 12 districts of Himachal Pradesh. It is located in the central part of Himachal Pradesh. The district lies between 31º 20′ 25″ and 32º 25′ 01″ north latitude and 76º56′ 30″ and 77º 52′ 20″ east longitude. It is bounded on the north and east by Lahaul and Spiti district, on the south east by Kinnaur district, on the south by Shimla district, on the south-west and west by Mandi district and on the north-west by Kangra district. The total geographical area of this region is 5503 square kilometers, which constitutes 9.88% of the total geographical area of Himachal Pradesh. Kullu district is situated in the transition zone between the Greater Himalayas and the Middle Himalayas, encompassing diverse valley regions to high mountainous terrains. (A Village Level Climate Change Vulnerability Analysis and Indicative Adaptation Plan Beas River Basin, 2019-20). The elevations range from 714 meters to 6632 meters above sea level, with its northern and northeastern regions mostly covered in snow throughout the year. The Beas River, originating near the Rohtang Pass in the Pir Panjal range, flows through the Kullu Valley and enters the Mandi district near Bajaura. The Parvati, Sarvari, Fojal, Solang, and Hurla are major tributaries of the Beas. (J.M. Balokhra, 2019) The climate here is predominantly temperate and cold, experiencing three seasons annually: summer (March to June), rainy (July to September), and winter (October to February). The region's approximately 80% population depends on agriculture and horticulture. Besides agriculture and horticulture, animal husbandry, tourism, and handicrafts contribute significantly to household income. Administratively, Kullu district falls under the Mandi division and comprises 5 blocks, 6 tehsils, 204-gram panchayats, 314 inhabited villages, and 12 uninhabited villages. As per the 2011 census, the total population is 437,903, consisting of 225,452 males and 212,451 females. (District census handbook, 2011)

Database and Methodology

In this research, both primary and secondary data have been used. The researcher has identified the service centers by visiting the study area through primary field survey. Secondary data has been obtained from District census handbook-2011, District statistical abstract Kullu-2022-23 and block indicator Kullu-2021-22. In this research, the researcher used the method developed by Dr. S.L. Kayastha and B.N. Singh (1981) to identify service centers. Dr S.L. Kayastha and B.N. Singh (1981) have outlined the following criteria for identifying service centers, namely, (a) The service center should be a permanent settlement with a population of 500 or more. (b) Any three functions out of education, medical, transport, communication and administrative services, (c) Which has its own area of influence whose residents depend on it for their social and economic services, (d) At least 0.25 percent of the population is engaged in business activities, Using this method, 172 service centers were identified in Kullu district. The researcher identified these centers through a primary survey. To measure the centrality of service centers in Kullu district, the researcher employed the weighted index method proposed by L.S. Bhatt and S.P. Mishra (1981). According to this method, the functions of the service centers were first assigned weighted scores based on their importance. Following that, the functional centrality index for all the service centers was calculated.

$$Wi = \frac{\mathrm{N}}{\mathrm{Fi}}$$

Wi = Weightage score of function in service centre, N = Total no. of service centres, Fi = No. of service centres having that function. A weighted scoring formula has been applied to assess the 37 activities carried out in the service centers of Kullu district, ranking them according to their importance (Table-1 and Fig. 1).

Table-1: Weighted Score of Selected Services in Kullu District

Functional Group	S. No.	Selected Services	Weighted Score
(1) Education	1	Primary school	1
	2	Middle School	1.35
	3	High School	3.07
	4	Senior secondary school	1.79
	5	College	24.57
	6	ITI	24.57
(2) Health	7	Primary health centre	5.37
	8	Primary health sub-center	1.66
	9	Dispensary	2.02
	10	Drugstore	2.45
	11	Maternal and child welfare centre	10.11
	12	Family welfare centre	43
	13	Allopathic hospital	28.66
	14	Ayurvedic Hospital	86
	15	Veterinary hospital	8.6

Contd...

(3) Transportation	16	Bus Stop	1.07
	17	Bus Stand	24.57
	18	Helipad	43
	19	Airport	172
(4) Communication	20	Post office	1.84
	21	Sub-Post office	1.31
	22	Telephone	1.12
	23	Mobile phone	1
	24	Common service centre	8.6
	25	Newspaper	1.13
(5) Marketing	26	Wholesale market	21.5
	27	Retail market	1.21
	28	Fruits and vegetable market	19.11
	29	Grain distribution centre	1.32
(6) Banking	30	Bank	1.33
	31	Agriculture credit society	1.81
(7) Administration	32	Panchayat headquarter	2.02
	33	Municipality / Nagar panchayat	28.66
	34	Tehsil headquarter	28.66
	35	Block headquarter	34.4
	36	District headquarter	172
	37	Police station	21.5

Source: Author

To determine the centrality of the service centers, we first assign different functional weightage scores to each center based on the importance of the services they offer. Then, we divide the individual functional weightage score of each service center by the total weightage score of all service centers. and multiplied by 100.

$$FCI = \sum_{i}^{n} \frac{Wid}{w} \times 100$$

FCI = Functional centrality index of service centre, Wid = Weightage for dth centre, W = Total weightage of all service centres.

Following the data collection phase, an extensive analysis was conducted utilizing maps and diagrams. Data analysis was performed using Microsoft Excel, while the mapping processes employed ArcGIS, QGIS 2.18, and Google Earth Pro software. The researcher consulted a diverse array of government reports, scholarly publications, and academic articles to inform and substantiate the analysis.

Result and Discussion

Spatial Distribution of Service Centres

The distribution pattern of service centers, like that of residences, is influenced by various physical, social, cultural, and economic factors. In areas with flat, homogeneous, and uniform terrain, coupled with similar socio-economic activities, the distribution of service centers tends to be regular. However, in regions with uneven terrain and diverse socio-economic characteristics, the distribution of service centers is irregular (R.C. Tiwari, 2006). In the Kullu district, the number of service centers is higher in the flat valley areas, while the hilly regions have significantly fewer service centers. The highest concentration of service centers is found in the northwestern part of the district, which encompasses the fertile Beas River valley. This area has a dense population and is better equipped to provide various basic facilities to the people. Therefore, there has been greater development of service centers in certain areas of Kullu District, while the concentration is lower in the southern and southwestern regions. These areas are predominantly mountainous, leading to an uneven distribution of service centers. The eastern part of the district also lacks service centers due to its cold climate and the challenging, inaccessible Himalayan terrain, which is less suitable for human settlement. Kullu District has 172 service centers, but their distribution is quite uneven. The highest concentration is found in the Naggar development block, with 56 service centers (32.56%), while the Nirmand development block has the fewest, with 15 centers (8.72%). Additionally, there are 48 service centers (27.91%) in the Kullu development block, 36 (20.93%) in Banjar, and 17 (9.88%) in Ani. (Table-1 and Fig. 1).

Centrality and Hierarchy of Service centres

Centrality of Service Centres

The term "centrality" refers to the relative significance of a service center in comparison to other service centers in the vicinity. This significance is determined by two main factors: the variety and number of functions performed by the service center, and the importance of those functions. Centrality serves as a reflection

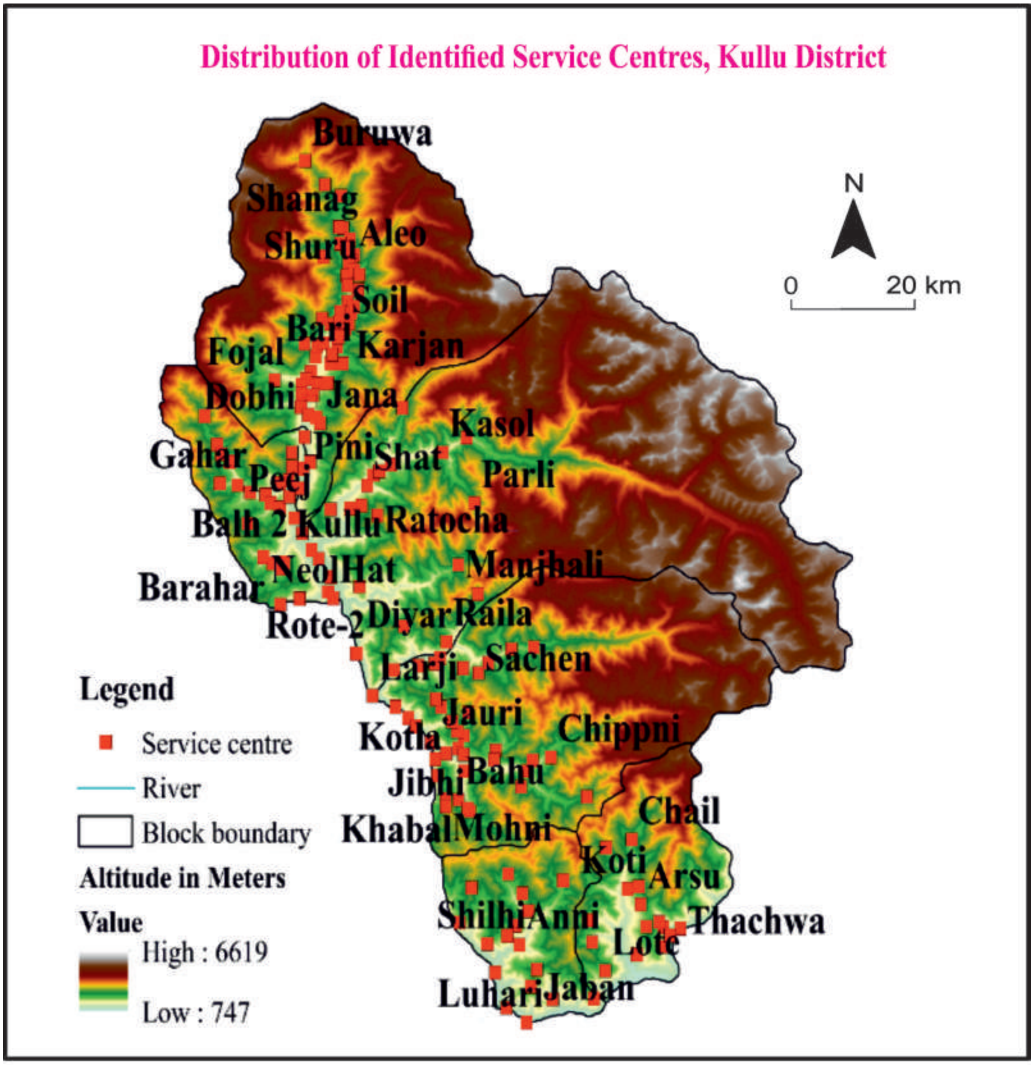
Distribution of Identified Service Centres, Kullu District
Buruwa
Shanag
Shuru
Aleo
Soil
Bari
Fojal
Karjan
Dobhi
Jana
Kasol
Gahar
Pini
Shat
Parli
Peej
Balh 2
Kullu
Ratocha
Barahar
Neol
Hat
Manjhali
Rote-2
Diyar
Raila
Larji
Sachen
Jauri
Kotla
Chippni
Jibhi
Bahu
Khabal
Mohni
Chail
Koti
Arsu
Shilhi
Anni
Thachwa
Lote
Luhari
Jaban
N
0
20 km
Legend
Service centre
River
Block boundary
Altitude in Meters
Value
High : 6619
Low : 747

Fig. 1

of consumer behaviour within a specific area, indicating how people utilize and prioritize different service centers. As a result, service centers are often organized in a hierarchical structure based on their centrality. Service centers with high centrality are considered more significant than other nearby centers. A service center achieves high centrality when it offers specific functions and services that are not available at other centers in the area. This unique offering increases its importance within the local community.

Measurement of Centrality of Service Centres

The centrality of service centers is evaluated based on the primary functions they provide. Geographers utilize different approaches to determine the centrality of these centers. Typically, Indian geographers emphasize the population's participation in commercial and tertiary services as a key factor in assessing a service center's centrality. (Singh, 1966a Singh, 1971a Singh, 1977) Some geographers have considered the fulfillment of people's needs from the services provided by the service center as the basis for this determination. (Sen et al., 1971a Kayastha and Mishra, 1981a Mishra, 1985) Most of the Indian geographers have used the weighted index method. According to this method, the functions of the service centers were first assigned weighted scores based on their importance. Following that, the functional centrality index for all the service centers was calculated (Fig. 2).

Hierarchy of Service Centres

The hierarchy of service centers is determined based on the Functional Centrality Index (FCI). First, the service centers are ranked from highest to lowest based on their Functional Centrality Index (FCI). Then, different categories are created. Using this method, the service centers in Kullu district are divided into five categories. Service centers are ranked by their importance, measured by the Functional Centrality Index (FCI). This index shows how central each service center is to the community. After ranking, the centers are grouped into five categories, from the most important to the least.

(a) First Order Service Centres

First order service centers are those with a Functional Centrality Index (FCI) of 4.50 or higher. In Kullu district, there are six such centers: Kullu, Bhuntar, Manali, Banjar, Nirmand, and Ani. These centers offer an average of 25.32 services

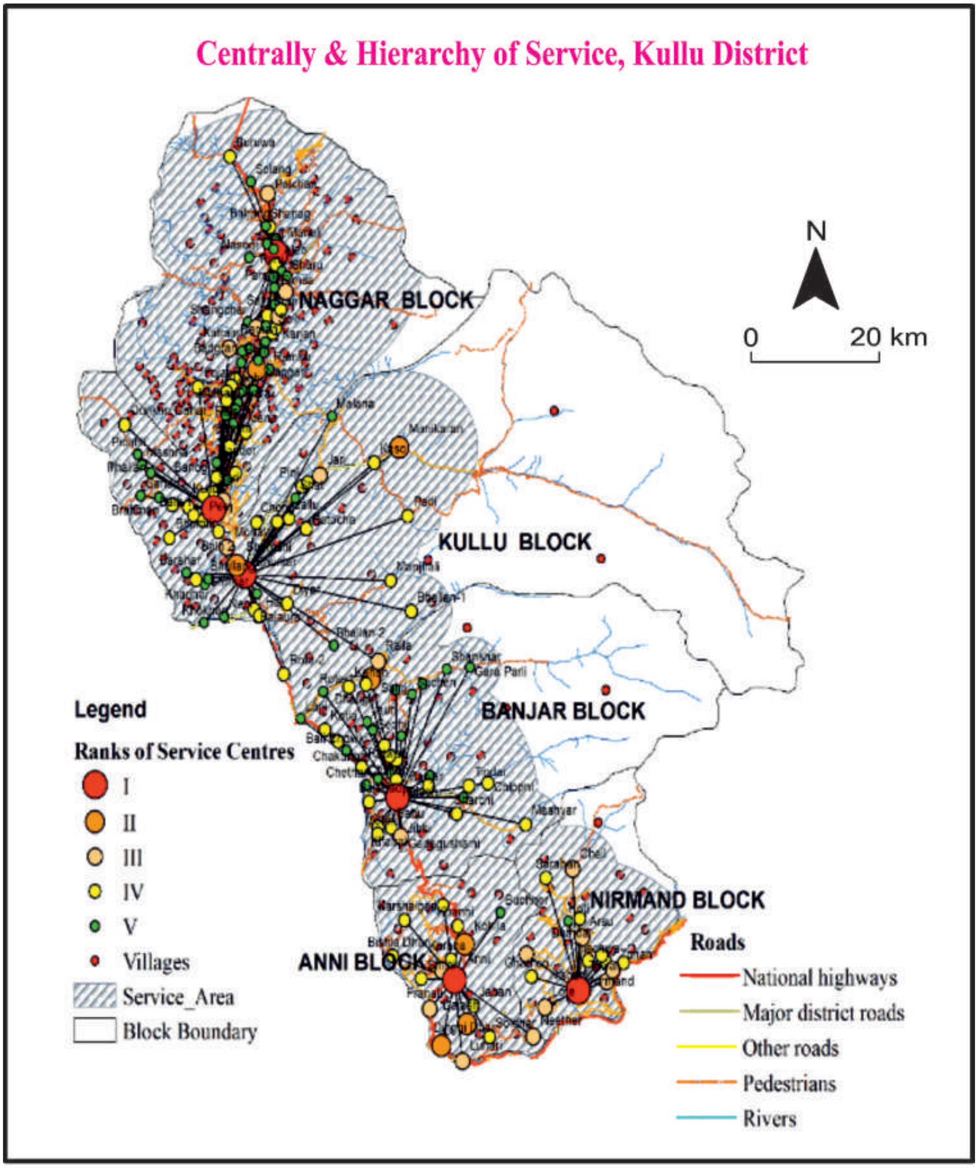
Centrally & Hierarchy of Service, Kullu District
N
0
20 km
NAGGAR BLOCK
KULLU BLOCK
BANJAR BLOCK
NIRMAND BLOCK
ANNI BLOCK
Legend
Ranks of Service Centres
I
II
III
IV
V
Villages
Service_Area
Block Boundary
Roads
National highways
Major district roads
Other roads
Pedestrians
Rivers

Fig. 2

out of the 37 identified services, ranging from basic to advanced services. Lower order service centers rely on these first order centers for higher-level services. Key facilities available at these centers include district and tehsil headquarters, police stations, regional hospitals, colleges, industrial training, transport and communication hubs, wholesale markets, and banking services.

(b) Second Order Service Centres

Service centers with a Functional Centrality Index (FCI) between 1.50 and 4.50 are classified as second order service centers. In Kullu district, there are seven such centers: Naggar, Shamshi, Manikaran, Sainj, Dalash, Dingi Dhar, and Kohila. These centers provide approximately 14.21 types of services, including facilities such as senior secondary schools, veterinary hospitals, dispensaries, bus stops, banks, and agricultural credit societies.

(c) Third Order Service Centres

Service centers with a Functional Centrality Index (FCI) between 0.50 and 1.50 are classified as third order service centers. There are 21 such centers in the district, including Pangan, Palchan, Haripur, Katrai, Mohal, Jari, Kharahal, Jagatsukh, Manjhadesh, Sajla, Franali, Nethar, Tawar, Raila, Arsu Chaul, Gadagushani, Tunan, Lote, and Kungsh. These centers offer around 12.18 types of services, including higher secondary education, dispensaries, bus stops, sub post offices, and retail trade, among others.

(d) Fourth Order Service Centres

Service centers with a Functional Centrality Index (FCI) between 0.25 and 0.50 are classified as fourth order service centers. In Kullu district, there are 73 such centers, including Bishla Dhar, Poshana, Balagad, Dayar, Kasargad, Karana Soidhar, Bran, Banogi, Kashawari, Bhallan-1A Sari, Bhalyani, Balh, Chong, Canon, Dhaugi, Chippani, Ghathu, Kasauli, Bajaura, Hat, Jaban, Ratwah, Sarahan, Bandrol, Bahu, Kasol, Seubagh, Peez, Kotla, Baruva, Dunkhri Gahar, Khadihar, Mashyar, Jallu, Dughilag, Pini, and Shilli, among others. These centers provide between 8 to 15 types of services, including secondary education, primary health centers, retail trade, and similar facilities.

(e) Fifth Order Service Centres

Service centers with a Functional Centrality Index (FCI) of less than 0.25 are classified as fifth order service centers. In Kullu district, there are 65 such centers, including Jandor, Pali, Barahar, Gara Parli, Sarseir, Shangadh, Larji, Nasogi, Mashna, Shat, Prini, Malana, Badgra, Larankelo, Gadherani, Archhandi, Jiji, Gushaini, Biasar, Shanshar, Solang, Shuru, Bashisht, Chhaki, Rampur, and Syal, among others. These centers offer approximately 5.13 types of services, mainly providing basic services such as primary education, first aid, telephone access, grocery shops, and Panchayat facilities. For higher-level services, they rely on service centers ranked above them.

Conclusion

This study thoroughly examined the distribution and importance of service centers in Kullu District, Himachal Pradesh, emphasizing their vital role in regional development. The results show that service centers act as key hubs that provide goods, services, and information, mainly benefiting nearby rural areas. By identifying 172 service centers, the research revealed a clear hierarchy: six top order centers provide advanced services, while many lower order centers offer basic facilities. The uneven spread of service centers, mainly found in the fertile Beas River valley and the Naggar block, illustrates how geography and socio-economic factors impact access to services. This analysis highlights the need for coordinated regional planning to improve service availability in less developed areas, especially in the district's southern and eastern regions. By understanding the importance and functions of these service centers, policymakers can develop strategies to enhance regional development, ensuring that rural communities have fair access to essential services and promoting sustainable growth throughout Kullu District. To enhance the service centres in Kullu District, this research highlights several key areas for improvement. One suggestion is to focus on the uneven distribution of service centres, particularly in the southern and eastern parts of the district, which have fewer centres due to challenging terrain and lower accessibility. Policymakers should consider investing in infrastructure development, such as improving road networks and communication facilities, to make these regions more accessible. By addressing the geographic barriers, the service centres in these areas could be better integrated with the rest of the district, improving access to essential services for the local population. Additionally, initiatives that promote economic activities like tourism, agriculture, and small-scale industries could help boost the demand for services, making it feasible to establish more service centres in these underdeveloped areas. Another key area for improvement is upgrading the existing service centres to offer a wider range of facilities. For example, second- and third-order centres should be equipped with better healthcare, education, and administrative services to reduce the reliance on higher-order centres. This could involve setting up telemedicine services, expanding vocational training programs, and improving financial services. Strengthening the centrality of service centres in underserved regions would create a more balanced service provision system, ultimately contributing to more equitable regional development. This research encourages policymakers to adopt a holistic approach to planning, one that prioritizes service expansion in both high-density and remote rural areas to ensure sustainable development across Kullu District.

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DEMOGRAPHIC TRANSITION IN LUCKNOW DISTRICT: A COMPREHENSIVE ANALYSIS

Vivek Kumar and Dr. S.P. Asthana

Abstract

This research delves into the demographic transition of Lucknow District, offering an exploration of its population dynamics from 2001 to 2011. The study comprehensively analyses various demographic indicators, unravelling intricate trends within the district. Urbanization and migration, pivotal dimensions of demographic change, are examined to understand their contributions to the evolving demographic landscape. The research identifies challenges associated with rapid urbanization, including strains on infrastructure, heightened resource demand, and socio-economic disparities. Methodologically, the research relies on secondary data from reliable sources such as government reports, statistical databases, and research publications. The blockwise population data, decadal growth rates, and sex ratio trends contribute to a comprehensive understanding of Lucknow District's demographic composition. This research aims not only to unravel the demographic intricacies of Lucknow District but also to shed light on the urbanization and migration dynamics. The findings provide a foundation for informed decision-making, guiding policymakers, urban planners, and community stakeholders in devising strategies for sustainable development amidst the challenges of rapid urbanization. Through this comprehensive exploration, the research seeks to contribute to the balanced and resilient future of Lucknow District in the face of ongoing demographic transitions.

Introduction

The demographic transition of Lucknow District encapsulates a multifaceted evolution in population dynamics, offering a nuanced understanding of its demographic landscape. This comprehensive analysis aims to delve into various demographic indicators, unravelling the intricacies of population trends and patterns within the district. By scrutinizing factors such as population growth, this research

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aspires to paint a vivid picture of the demographic shifts over time. Urbanization and migration constitute pivotal dimensions of demographic change, and this study endeavours to dissect their roles in shaping the demographic contours of Lucknow District. Through a meticulous examination of the urbanization process, the research seeks to elucidate how migration, both internal and external, contributes to the demographic fabric of the district. Understanding the interplay between these factors is crucial for gaining insights into the transformative journey of Lucknow's population dynamics. This research embarks on a comprehensive exploration, aiming not only to unravel the demographic intricacies but also to shed light on the urbanization and migration dynamics within Lucknow District. Through this endeavour, a holistic understanding of the challenges posed by rapid urbanization will be cultivated, paving the way for informed interventions and sustainable development initiatives.

Study Region

Lucknow district is a district located in the state of Uttar Pradesh in northern India. The city of Lucknow is the district headquarters and the district is part of Lucknow Division. It also is the capital of Uttar Pradesh. Lucknow is Bounded on the east by Barabanki district, on the west by Unnao and Hardoi districts, on the south by Raebareli district and in the north by Sitapur district. It is geographically located between latitude 26° 30' North and longitude 80° 30' East. Lucknow district covers an area of 2,528 square kilometres, centrally located in both the central Ganges plain as well as Uttar Pradesh as a whole. The climate of Lucknow district is predominantly subtropical in nature, and it experiences the effects of the South Asian monsoon. Lucknow district is divided into 4 tehsils: Lucknow, Malihabad, Mohanlal Ganj, and Bakshi Ka Talab. These tehsils are then divided into 8 community development blocks. According to the 2011 census Lucknow district has a population of 4,589,838. This gives it a ranking of 31st in India (out of a total of 640). The district has a population density of 1,815 inhabitants per square kilometre (4,700/sq. mi). Its population growth rate over the decade 2001-2011 was 25.79%. Lucknow has a sex ratio of 906 females for every 1000 males, and a literacy rate of 79.33%. 66.21% of the population lived in urban areas. According to the 2001 census Lucknow district had a population of 3,681,461.

Objectives

(1) To explore demographic indicators to provide an insight of the District’s demographic landscape.

(2) To examine the urbanization and migration contribution to demographic change.
(3) To identify challenges associated with rapid urbanization.

Database and Methodology

This research paper is based solely on secondary data. The approach involves a systematic and structured process for collecting, analysing, and interpreting existing information. Secondary data from reliable sources such as government reports, statistical databases, academic journals, and research publications has been used for collection of data. Demographic data, urbanization statistics, and agricultural land use information has been collected. A comparative analysis of urban and rural areas within Lucknow District to discern differences in agricultural land use patterns has been done. By relying on secondary data, this research methodology aims to provide a comprehensive understanding of the complex relationships between population density, urbanization, and agricultural land use in Lucknow District.

Results and Discussion

The blockwise population data for Lucknow district in 2011 provides insights into the demographic composition of the region. Notably, Bakshi ka Talab stands out with the highest total population of 239,938, indicating its significance in terms of inhabitants. Mohanlal Ganj follows closely with a population of 248,512. On the other end, Chinhat has the lowest total population among the listed blocks at 134,819 (Table-1 and 2).

Table-1: Population of Lucknow District, 2011

Blocks	Total Population	Male	Female
Malihabad	179673	94343	85330
Mall	172949	90613	82336
Bakshi ka Talab	239938	126133	113805
Kakori	154272	81224	73048
Chinhat	134819	70332	64487
Sarojininagar	224045	117745	106300
Gosainganj	196634	102131	94503
Mohanlal Ganj	248512	131231	117281
Total	4589838	2394476	2195362

Source: Census of India, 2011

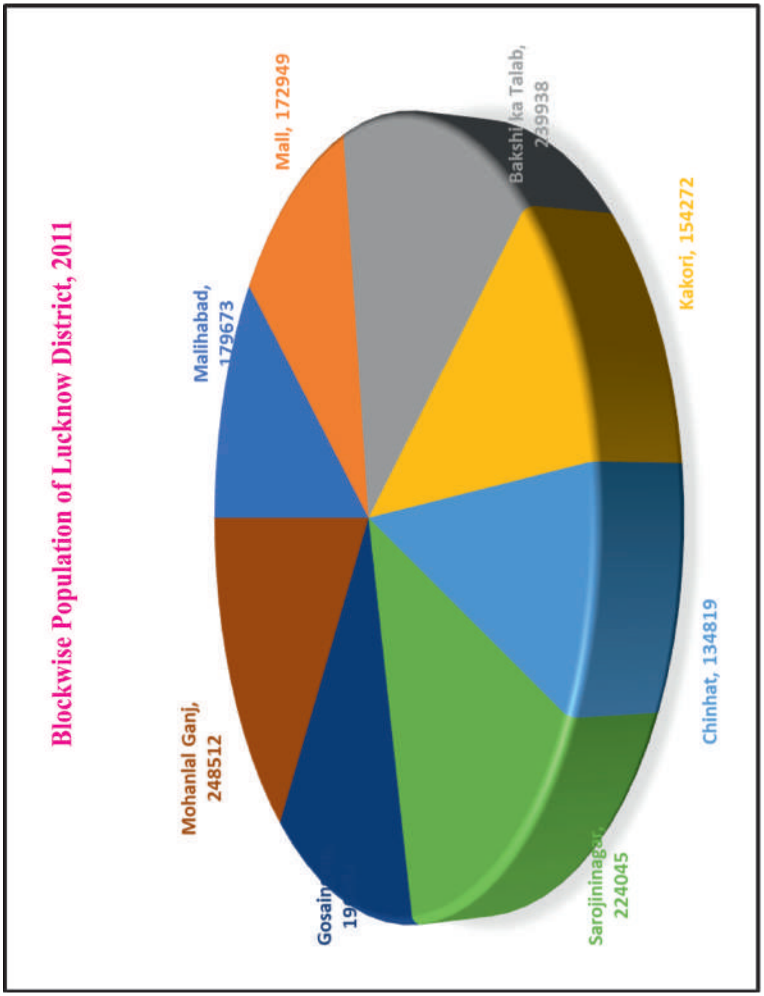
Blockwise Population of Lucknow District, 2011
Mohanlal Ganj, 248512
Malihabad, 179673
Mall, 172949
Bakshi ka Talab, 239938
Kakori, 154272
Chinhat, 134819
Sarojininagar, 224045
Gosain

Fig. 1

Despite variations in total population, a consistent trend emerges with a higher male population across all blocks. Examining gender distribution, it's evident that males outnumber females in each block (Fig. 2). This gender imbalance is reflective of broader demographic patterns often seen in various regions. Sarojininagar and Bakshi ka Talab, with significant differences in male and female populations, exemplify this trend. The data underscores the need for a nuanced understanding of gender dynamics in urban planning and resource allocation.

Table-2: Decadal Growth of Population of Lucknow District

Years	Decadal Percentage Change		
	Total	Rural	Urban
1901	0.0	0.0	0.0
1911	-4.0	-4.0	-2.0
1921	-5.0	-4.0	-8.0
1931	9.0	6.0	14.0
1941	21.0	10.0	39.0
1951	19.0	14.0	25.0
1961	19.0	11.0	27.0
1971	21.0	18.0	24.0
1981	25.0	20.0	29.0
1991	37.1	8.0	63.4
2001	32.0	24.9	36.3
2011	25.8	20.4	28.8
(1901- 1991)	248.3	106.1	491.6

Source: Census of India, 2011

The provided data outlines the decadal growth of the population in Lucknow district over the years, spanning from 1901 to 2011. The decadal percentage change is presented for the total population, as well as separately for rural and urban populations (Fig. 2). Examining the trends, the initial decades from 1901 to 1931 witnessed relatively modest changes, with fluctuations and a marginal decline in the 1911 and 1921 census. However, a notable surge in population growth occurred in 1931, where the total population increased by 9%, with rural and urban areas experiencing growth rates of 6% and 14%, respectively. The following decades up to 1951 continued to show substantial growth, with the urban population consistently

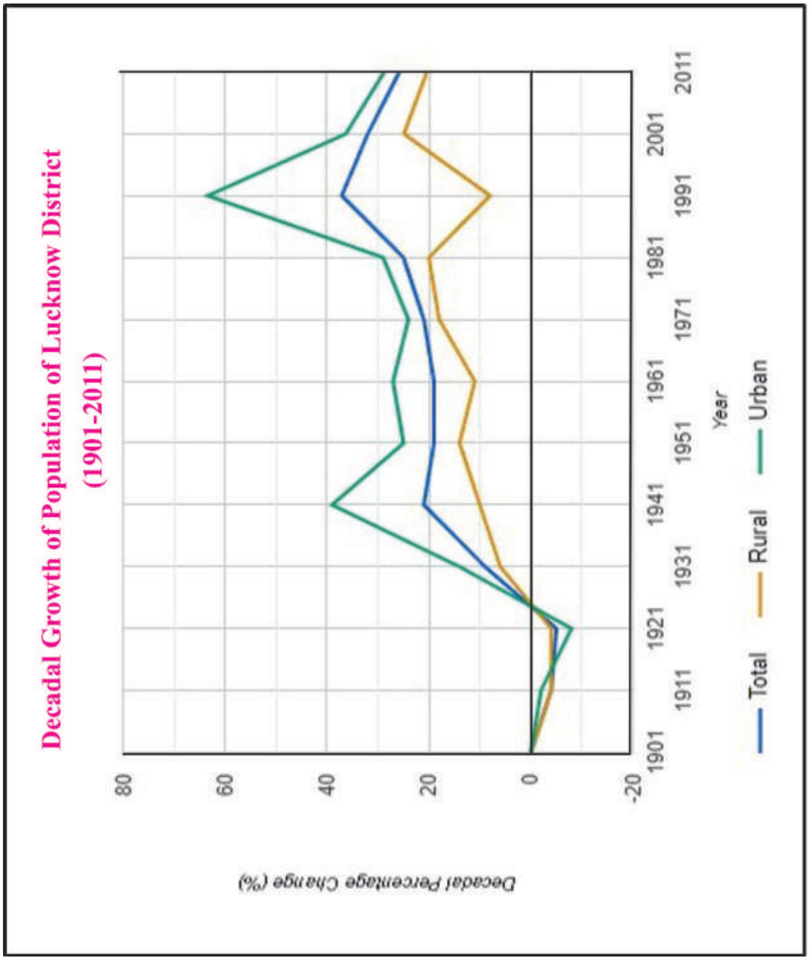
Decadal Growth of Population of Lucknow District
(1901-2011)
Decadal Percentage Change (%)
80
60
40
20
0
-20
1901
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011
Year
Total
Rural
Urban

Fig. 2

outpacing rural growth. The period from 1951 to 1991 marked significant overall population expansion, characterized by double-digit growth rates, especially in urban areas. The urban population saw a remarkable surge in 1991, with a 63.4% increase, while the rural growth rate remained comparatively lower at 8%. This urban-centric growth trend continued into the early 2000s, as evidenced by the 2001 census, which recorded a 24.9% increase in urban population compared to 20.4% in the total population. However, the decadal growth rates showed a declining trend in 2011, with the total population growing by 25.8%, comprising 20.4% rural and 28.8% urban growth (Table-3). This suggests a potential stabilization or moderation in the population growth compared to previous decades. The cumulative percentage change from 1901 to 1991 highlights a substantial overall increase of 248.3%, with urban areas experiencing a remarkable growth of 491.6%, emphasizing the dynamic shift towards urbanization during this period. In summary, the data reflects a historical evolution in Lucknow district's population dynamics, marked by phases of moderate growth, significant urbanization, and a recent trend of deceleration in growth rates. Understanding these patterns is crucial for informed policymaking, urban planning, and resource allocation in the region.

Table-3: Sex Ratio of Lucknow District

Year	Total	Rural	Urban
1901	912	923	893
1911	856	809	886
1921	845	879	788
1931	819	872	739
1941	819	881	746
1951	842	890	789
1961	839	889	790
1971	841	854	829
1981	847	862	834
1991	866	857	871
2001	888	887	888
2011	917	906	923

Source: Census of India (1901-2011)

The data provides the sex ratio of Lucknow district over the years from 1901 to 2011, segmented into total, rural, and urban categories. Sex ratio is a key demographic indicator, representing the number of females per 1,000 males in a population. Analysing the trends, it is evident that the sex ratio in Lucknow district has undergone fluctuations across different periods. In 1901, the total sex ratio was 912, with rural and urban areas showing values of 923 and 893, respectively. Over the following decades, a general decreasing trend in sex ratio is observed, reaching a low point in 1931 with values of 819, 872, and 739 for total, rural, and urban areas, respectively. From 1941 onwards, there is a gradual recovery in the sex ratio, particularly in rural and urban areas. Notably, the sex ratio in urban areas consistently lags behind that of rural areas, indicative of potential gender dynamics influenced by urbanization. The sex ratio in rural areas remains comparatively stable over the years. In 1991, there is a notable improvement in sex ratios across all categories, with the total sex ratio reaching 866, and both rural and urban areas showing increases. This positive trend continues in the subsequent decades, culminating in the 2011 census where the total sex ratio is reported as 917, with rural and urban areas showing values of 906 and 923, respectively. The overall upward trend in sex ratios, especially in the later decades, is a positive indicator of a potential improvement in gender balance in Lucknow district (Table-4). However, the persistent disparity between rural and urban areas underscores the need for targeted interventions and policies to address gender imbalances in the context of urbanization and development. Further analysis and research would be beneficial to understand the underlying factors contributing to these trends and to inform gender-sensitive planning and initiatives in the region.

Table-4: Volume of Internal In-migrants in Lucknow District, 2001-11

Migrants	2001			2011		
	Total	Rural	Urban	Total	Rural	Urban
Total Internal In-Migrants	1016448	335431	681017	1840131	455036	1385095
% of Total Population	27.86	25.28	29.34	40.09	29.34	45.58

Source: Migration Tables, Census of India 2001-11

The data presents the volume of internal in-migrants in Lucknow District for the years 2001 and 2011, categorized into total, rural, and urban segments. Additionally, the percentage of total population represented by these in-migrants is provided for each category. In 2001, the total volume of internal in-migrants was 1,016,448, comprising 335,431 in rural areas and 681,017 in urban areas.

This accounted for 27.86% of the total population, with 25.28% in rural areas and 29.34% in urban areas. Over the decade, there was a substantial increase in internal in-migration, reaching a total of 1,840,131 in 2011. Rural in-migrants increased to 455,036, while urban in-migrants surged to 1,385,095. This represented 40.09% of the total population, with rural and urban in-migrants constituting 29.34% and 45.58%, respectively. The data reflects a significant rise in the volume of internal migration in Lucknow District over the decade, indicating dynamic demographic shifts. The noticeable increase in the percentage of total population represented by internal migrants, especially in urban areas, suggests the growing influence of migration on the district's population composition. Several factors may contribute to this trend, such as economic opportunities, urbanization, and infrastructure development. Urban areas, in particular, appear to attract a higher proportion of internal migrants, possibly due to employment prospects and better amenities. Policymakers and urban planners should consider these migration patterns when formulating strategies for sustainable development, infrastructure provision, and social services in Lucknow District (Table-5). Further research into the specific drivers of internal migration and its impact on the socio-economic landscape would provide valuable insights for informed decision-making. The data provides insights into the types of migrants in Lucknow District, their proportion by place of enumeration, and the growth rates from 2001 to 2011. The migrants are categorized into three types: Intra-District, Inter-District, and Inter-State.

Table-5: Proportion and Growth of migrants in Lucknow District, 2001-11

Types of Migrants	Migrants (%) by Place of Enumeration						Growth Rate (%)		
	2001			2011			2001-11		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Intra- District	34.96	66.92	19.21	45.58	64.93	39.22	136.06	31.62	315.27
Inter- District	52.12	28.90	63.55	46.47	32.64	51.01	61.41	53.21	63.25
Inter- State	12.93	4.18	17.24	7.95	2.43	9.77	11.36	-21.0	15.23

Source: Migration Tables, Census of India 2001-11

(a) Intra-District Migrants: In 2001, they constituted 34.96% of the total migrants, with 66.92% in rural areas and 19.21% in urban areas. By 2011, these proportions increased to 45.58%, 64.93%, and 39.22%, respectively. The growth rate for total intra-district migrants during this period was substantial at 136.06%, with rural and urban areas showing growth rates of 31.62% and 315.27%, respectively.

(b) Inter-District Migrants: In 2001, inter-district migrants represented 52.12% of the total, with 28.90% in rural areas and 63.55% in urban areas. By 2011, these proportions changed to 46.47%, 32.64%, and 51.01%, respectively. The growth rates for total, rural, and urban inter-district migrants were 61.41%, 53.21%, and 63.25%, indicating a notable increase.

(c) Inter-State Migrants: In 2001, inter-state migrants comprised 12.93% of the total, with 4.18% in rural areas and 17.24% in urban areas. By 2011, these proportions changed to 7.95%, 2.43%, and 9.77%, respectively. The overall growth rate for inter-state migrants was 11.36%, with a decline in rural areas (-21.0%) and an increase in urban areas (15.23%). The data reveals a substantial increase in the total volume of migrants in Lucknow District from 2001 to 2011. Intra-district migration experienced the highest growth, particularly in urban areas, suggesting significant urbanization and internal mobility. Inter-district migration also increased, with notable growth rates across total and urban categories. However, inter-state migration saw a decline in rural areas but an increase in urban areas. Understanding these migration patterns is crucial for local authorities and policymakers. The rise in intra-district migration emphasizes the need for urban planning and infrastructure development to accommodate the growing urban population. Inter-district migration trends can inform regional development strategies, while the dynamics of inter-state migration require nuanced policy considerations to address the differential trends in rural and urban areas.

Urbanization and Population Density in Lucknow District

In 2001 Lucknow District had a total population of 3,681,461, the population density was 1453 persons/sq. km. The urbanized population was 63.3%. In 2011, the total population of Lucknow District increased to 4,589,838 and the population density increased to 1815 persons/sq. km. The urbanization was 66.21%. The decadal population growth rate between 2001 to 2011 was 25.79%.

Contribution of Urbanization and Migration in the Demographic Change in the District

The decade from 2001 to 2011 in Lucknow District witnessed a notable evolution in population dynamics, primarily influenced by migration and urbanization. Analysing the provided data, it is evident that both migration and urbanization played pivotal roles in shaping the population landscape of the district.

Urbanization, as indicated by the rise in the urbanized population from 63.3% in 2001 to 66.21% in 2011, underscores the significant impact of urban development. The increased urbanization rate signifies a growing concentration of people in urban areas, reflecting shifts in lifestyle, economic activities, and infrastructural development. This phenomenon is indicative of the district's urban expansion and the allure of urban living. Migration, can be inferred as a contributing factor to the substantial population growth observed during the decade. The decadal population growth rate of 25.79% suggests that the district experienced a considerable influx of people, possibly through both internal and external migration. Migration, driven by factors such as employment opportunities, educational facilities, and improved living standards in urban areas, likely played a crucial role in augmenting the overall population of Lucknow District. The increased population density from 1453 persons per square kilometre in 2001 to 1815 persons per square kilometre in 2011 further accentuates the combined impact of urbanization and migration. The higher density reflects the intensified clustering of people, particularly in urban centres, resulting from both natural growth and migratory patterns.

Challenges Associated with Rapid Urbanization

Rapid urbanization in Lucknow District, as evidenced by the increase in urbanization from 63.3% in 2001 to 66.21% in 2011, brings forth a host of challenges that demand careful consideration and strategic interventions. The challenges associated with this swift urban development encompass various aspects, ranging from infrastructure strain to socio-economic disparities. One prominent challenge is the strain on infrastructure. As urbanization accelerates, there is often an increased demand for basic amenities such as housing, transportation, water supply, and sanitation. The existing infrastructure may struggle to cope with the burgeoning population in urban areas, leading to issues like congestion, inadequate housing, and insufficient public services. Addressing these infrastructure challenges is crucial for ensuring the well-being and quality of life for the urban population. Another critical concern is the heightened demand for resources. Rapid urbanization often results in an increased consumption of resources such as energy, water, and land. This surge in demand can strain available resources, potentially leading to environmental degradation and affecting the sustainability of urban development. Sustainable resource management becomes imperative to mitigate these challenges and ensure a balance between urban growth and environmental preservation.

Socio-economic disparities also emerge as a challenge during rapid urbanization. While urban areas may attract economic opportunities, the benefits are not always distributed equitably. The influx of population can lead to the creation of informal settlements and slums, exacerbating social inequalities. Access to education, healthcare, and employment opportunities may become uneven, necessitating inclusive policies to address disparities and promote social cohesion. Furthermore, the process of rapid urbanization can contribute to increased land prices and housing costs, making affordable housing a significant challenge. This, in turn, can lead to issues of homelessness and inadequate living conditions for certain segments of the population.

Conclusion

The comprehensive analysis of the demographic transition in Lucknow District has provided valuable insights into the complex interplay of factors shaping its population dynamics. The examination of demographic indicators, urbanization, migration, and associated challenges has unravelled the intricate patterns and trends within the district. The demographic transition, reflected in the data from 2001 to 2011, showcased a significant evolution marked by substantial population growth, urbanization, and internal migration. Urbanization emerged as a dominant force, with the urbanized population increasing from 63.3% to 66.21%. The concomitant rise in population density highlights the intensified clustering of people in urban centres, indicating the allure and impact of urban living. Migration, both intra-district and inter-district, played a pivotal role in this demographic shift, contributing to the overall population growth of 25.79%. This research paper not only illuminates the demographic intricacies of Lucknow District but also provides a foundation for addressing the challenges posed by rapid urbanization. The understanding of migration patterns, types of migrants, and the impact of urbanization on infrastructure and resources is crucial for informed decision-making. As Lucknow District navigates its ongoing demographic transition, policymakers, urban planners, and community stakeholders must collaborate to devise inclusive strategies that ensure sustainable development, address disparities, and enhance the overall well-being of the population. Through this comprehensive exploration, the research aims to contribute to the informed interventions and initiatives necessary for guiding Lucknow District towards a balanced and resilient future amidst rapid urbanization.

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ECONOMIC ANALYSIS AND LIVELIHOOD IMPACT OF AGRICULTURE IN CHHATARPUR DISTRICT OF BUNDELKHAND REGION IN INDIA

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Abstract

Bundelkhand, a region characterised by its unique undulating topography, deprivation, and extreme climatic conditions, faces persistent drought and challenging agricultural livelihoods. Consequently, high soil loss through erosion and surface runoff, coupled with low agricultural productivity, has led to unsustainable livelihoods in the region. This study employs primary data gathered through a semi-structured questionnaire survey, utilising stratified random sampling from the Chhatarpur district in Madhya Pradesh and examines the input outputs cost of crops analysis to understand the livelihood condition in the area. The study highlights that the input-output cost analysis indicates that wheat, mustard, sesame, and black gram yield negative returns. Conversely, other crops such as groundnut, sorghum, and secale cereal demonstrate economic viability (Rs 1946 per ha). This study identifies several constraints to crop production, including water scarcity, traditional farming practices, limited technological advancements, and fragmented land holdings. It emphasises the crucial role of sustainability in agriculture for long-term prosperity. It proposes strategies to enhance productivity, promote sustainable practices, improve rural livelihoods and promote rural development in the Bundelkhand region of India.

Introduction

The origin of agriculture, a pivotal moment in human history, can be traced back approximately 11,000 years ago in the East. This transition from hunting and gathering to farming marked the emergence of agriculture in Europe, Asia, and North Africa (Rottenberg, 2017). The transition to agriculture marked a pivotal shift in human history, granting early farmers enhanced food production, social prestige,

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and influence (Milner & Boldsen, 2023). India is one of the earliest civilisations to have begun farming during the Indus Valley Civilization and has existed till now. Agriculture, the backbone of India's economy, is the largest employer and contributor to about 20% of the GDP, and approximately 60% of the population is dependent on this sector (Doria, 2023). Additionally, the Indian economy has relied heavily on agriculture for many decades (Kumari et al., 2017), and it is a crucial source of livelihood for many people in rural areas. Agriculture provides income surpluses over production costs (Singh & Shishodia, 2016) and plays a significant role in regions like Bundelkhand's social and economic development. It is an impoverished and least-developed region in India, And the livelihood of this region mostly depends on agriculture (Verma, 2021). Bundelkhand's economy mainly depends on agriculture, and its sources of livelihood are manifold and underutilised. For these reasons, there is an over-reliance on agriculture to provide for the livelihood of the population (NITI Aayog, 2012). A livelihood denotes the means of gaining a living. It also refers to employment and income-generating activities and seems synonymous with, and sometimes overlaps with, concepts associated with terms such as "employment" and "work." However, "livelihood" describes more complex and diverse agricultural activities (Chamber & Gordon, 1991). According to Haan & Zoomers (2003), "A livelihood is about individuals, households, or groups making a living, attempting to meet their various consumption and economic necessities, coping with uncertainties, and responding to new opportunities". The development of new and sustainable sources of income in agriculture in rural territories is not just a suggestion; it is a necessity for the prognosis of inclusive rural development (Mihai et al., 2020). However, livelihoods in these areas are in danger of various factors such as distress migration due to drought, a situation where people are forced to leave their homes and migrate to other areas due to severe water scarcity and its impact on agriculture, which intensifies socio-economic inequality (Anuja, 2018). However, these critical dry spell periods severely impact the agricultural sector, necessitating immediate attention and action.

This is evidenced by countries like Bundelkhand in India, which is informationally prone to natural disasters. Climate variability exacerbates natural resource vulnerability and acute water scarcity for crop production, frequently resulting in drought and deficit rainfall. Several constraints hinder the development of agricultural livelihoods in Bundelkhand, ranging from adverse weather conditions to inadequate infrastructure and institutional support (Kanianska, 2016).

These constraints limit poverty alleviation and become challenges to food security and achieving Sustainable Development Goals (SDGs), which are severely missed in this region. Mitigating agriculture problems from the Bundelkhand region of India requires a multifaceted approach due to challenges like low crop productivity, water scarcity, and socio-economic vulnerabilities. Moreover, adopting precision agriculture practices, remote sensing technologies, and soft computing methods can assist in optimising inputs, reducing costs, and enhancing crop management strategies (Upendra et al., 2020). Moreover, analysing the diversification opportunities of the crops mentioned and encouraging water-frugal crops such as pearl millet, sesame, and soybean will help to enhance water usage effectiveness in the study area (Kumar et al., 2021). Thus, by applying these intervention strategies and integrated pest management practices, Bundelkhand can try to phase through the existing agricultural problems, uplift the living standards of deprived rural farmers and make the Bundelkhand Region prosper like the medieval periods of India. It also suggests policies and interventions for inclusive rural development.

Study Region

The Chhatarpur district of Madhya Pradesh is the focus of this study, situated centrally in the Bundelkhand region. It is a part of the Sagar division and is positioned on the northeastern border of Madhya Pradesh. The district covers an area of 8,687 square kilometres, with longitudes and latitudes ranging from 24°06' to 25°20' in the north and 78°59' to 80°26' in the east. It extends up to 185 km in length and 121 km in width. The district is primarily located in the upper part of the Bundelkhand Plateau, with the most notable areas being those that intersect the Panna Hill Range in the southern parts. This range rises about 100 meters from its surroundings and is approximately 300 meters above mean sea level. The plateau descends towards the north and covers the alluvial plains, particularly along the Ken and Dhasan rivers. Consequently, the district can be divided into three physical regions: Panna, central plateau, and northern plains. According to the 2011 census, the district's population is 1,762,375, comprising 936,121 males and 826,254 females. In 2011, 356,297 families resided in the Chhatarpur district. The average sex ratio in the district was 883. The 2011 census also revealed that 22.6% of the population lived in urban areas, while 77.4% resided in rural areas. The average literacy rate in urban areas was 78.7%, while it stood at 59.2% in rural areas.

Objectives

(1) To analyse the input-output cost of crops in the Bundelkhand region and assess their impact on human livelihoods.

(2) To identify farmers' constraints in the Bundelkhand region and propose effective mitigation strategies to address these challenges.

Database and Methodology

The present study integrates both primary and secondary datasets to construct its foundation. The primary dataset was meticulously gathered by employing stratified random sampling techniques. Specifically, this involved the selection of six villages for an in-depth examination, namely, Maheba and Tudar from the Chhatarpur tehsil, along with Nayagaon, Mukarwa, Tidani, and Nanhimau from the Nowgaon tehsil, situated within the Chhatarpur District of the Bundelkhand Region. The study surveyed 80 households, ensuring a representative sample from each village. The research methodology also encompassed structured interviews with crucial village officials, including the sarpanch (village head) and the panchayat secretary. Secondary data sources were meticulously explored to augment the primary data, notably the Agriculture Contingency Plan for Districts and authoritative government records. These resources provided invaluable insights into the study region's agro-climatic zones, operational agricultural seasons, and crop diversity. The farming community predominantly consisted of marginal, small, and semi-medium-scale farmers, with a lesser proportion of medium and large-scale operators. To enhance the analytical depth of the study, a combination of empirical and statistical techniques was employed, facilitating a nuanced understanding of the prevailing challenges and their implications. The research further entailed a comprehensive collection of village-specific data concerning agricultural inputs and outputs. This included detailed records on seeds, irrigation, tillage, harvesting/weeding, fertiliser application, transportation, and the cost of human labour, alongside outputs such as market sales, domestic storage practices, and the sale of residues or straws.

A mathematical framework was adopted to ascertain the input and output costs associated with individual crops on a hectare-wise basis, expressed in monetary terms (Indian Rupees). Notably, the labour cost was standardised at ₹300 per person per day, reflective of the average labour cost within the area, with variations observed across different crops due to disparate growing periods. For instance, crops such as mustard, wheat, sesame, and black gram necessitated an average of 25 days of human labour, whereas shorter-duration crops like millets required an average of

15 days. These estimations were grounded in empirical data from farmer interviews and corroborated by the extant literature. Utilising the data above, the study conducted comprehensive input-output analyses for significant crops and delineated the livelihood dynamics predicated on agricultural practices within the study area.

Results and Discussion

Agricultural Scenario of District

The district's total geographical area spans 8687 km2, with 54.99% allocated for cultivation, encompassing net-sown and fallow lands. The net sown area accounts for 44.89% of the district's land, while forest cover occupies 13.69%, primarily concentrated in the southern region, leaving 44.9% for agricultural activities (Table 1). Approximately 44.2% of the net sown land is under irrigation, with Gaurihar, Londi, Buxawaha, and Bijawar exhibiting minimal irrigation facilities. Barren and uncultivable land constitute 10.73% of the district's area, while culturable wasteland and pastureland comprise 6.13% and 8.41%, respectively. Non-agricultural uses cover 5.52% of the land. The rural economy heavily relies on agriculture to sustain its inhabitants, necessitating a sustainable development approach. Vegetables and spices occupy 2.0% and 1.0% of the gross cropped area, respectively (Table-1). The district boasts a double-cropped area spanning 234,228 hectares, with a cropping intensity of 159%, surpassing both state and national averages of 155.1% and 141.6%, respectively.

Input- Output Cost Analysis

Agricultural inputs such as seeds, tillage, irrigation, weeding and harvesting, fertilisers, transportation, and human labour are essential in the input-output analysis. On the other hand, agricultural outputs include domestic storage and the monetary value of residue or straw. The input-output analysis of individual crops is given in (Table 2). For instance, the cost of seeds varies across different crops, with the lowest seed cost recorded in other crops (Rs. 1650 per ha) and the highest in crops like sesame (Rs. 2662 per ha) and wheat (Rs. 2597 per ha). In the cultivation of sesame and wheat, costs increase due to both being used for commercial and daily use, so farmers are not trying to compromise both.

Key challenges include poor soil fertility, low agricultural productivity, land distribution disparities, inadequate irrigation facilities, limited access to credit, market constraints, and the prevalence of unscientific farming practices, all contributing to significant migration trends.

Table-1: Landuse Pattern of Chhatarpur District of Madhya Pradesh

S. No.	Land Use	Area	
		(ha)	(%)
1	Forest Area	118,139	13.69
2	Barren and Uncultivable	92,581	10.73
3	Pastures	72,569	8.41
4	Land under Misc. Tree Crops	4,577	0.53
5	Culturable Waste Land	52,924	6.13
6	Fallow land	47,658	5.52
7	Current Fallow	39,501	4.58
8	Net Area Sown	387,408	44.89
9	Rainfed land	216,191	55.80
10	Total Area Irrigated	171,217	44.20
11	Area Under non-agriculture uses	47,679	5.52
	Total	863,036	100

Source: Extracted from (IGG, 2020)

The region's terrain and fragmented land distribution also influence input costs, as seen in the high tillage costs associated with wheat cultivation (Rs. 2213 per ha), and the lowest input cost of tillage is accounted for in the cultivation of mustard (Rs. 1157 per ha) in the study area. Similarly, irrigation costs are crucial in crop outcomes in the rainfed region, with wheat cultivation (Rs. 1993 per ha) requiring significant irrigation expenses because irrigation was needed 4-5 times during the entire wheat cultivation process in the rainfed region. Compared to crops like mustard (Rs. 926 per ha), irrigation is required only 1-2 times in the whole process. In this region, some artificial challenges coexist with natural challenges, such as the Pradhan Mantri Krishi Sinchai Yojana, which contribute to the complexity of agricultural practices in the area. The analysis also highlights differences in crops' harvesting, weeding, and threshing costs, with mustard cultivation exhibiting the highest average cost (Rs. 185 per ha). In contrast, black gram cultivation had the lowest (Rs. 84 per ha). Additionally, the use of chemical fertilisers is prevalent in the region due to the limited availability of compost fertilisers, with varying costs across different crops, such as sesame (Rs. 1662 per ha) and minimum in black gram (Rs. 1134 per ha) cultivation. Transportation costs have emerged as a critical factor in input-output cost analysis within agricultural systems. It is pivotal in determining farmers' access to markets to procure seeds and fertilisers and sell their crop yields.

Notably, in the context of the commercial cultivation of sesame, the average transportation cost as an input was observed to be lowest in black gram cultivation (Rs. 42 per ha) and highest in sesame cultivation (Rs. 273 per ha). This disparity can be attributed to the inadequate road connectivity to remote villages like Tudar in the Chhatarpur tehsil of the district. Labour input costs for cultivating black gram were the highest in the region at (Rs. 9454 per ha), while costs for other crops were lower at (Rs. 3393 per ha). This cost variation reflects the differing levels of human labour required for crop cultivation in Bundelkhand (Table-2). The labour cost per person per day is set at ₹300, based on the prevailing average labour cost in the region. The total labour cost for each crop varies due to its distinct growing period. For crops like mustard, wheat, sesame, and black gram, an average of 25 days of human labour cost was calculated. An average of 15 days of human labour cost was considered for millets and other crops with shorter growing periods.

Table-2: Annual Farming Budget of Agriculture in Chhatarpur District

Parameters	Black gram	Mustard	Sesame (Til)	Wheat	Other crops*
Inputs					
Seed	2269	2083	2662	2597	1650
Tillage	1513	1157	1929	2213	1401
Irrigation	1303	926	1326	1993	1106
Harvesting, weeding, and grinding/Threshing	84	185	114	140	93
Transportation	42	93	273	95	123
Fertiliser and Insecticide	1134	1389	1662	1626	1208
Human Labour	9454	4861	5492	6172	3393
(A) Total	15798	10694	13336	14836	8973
Outputs					
Sell in the market (Price)	8824	7037	6414	7323	6468
Domestic use (For family and animals use) (Price)	4244	3333	5303	7323	4365
Selling of straw/residue (Price)	294	74	247	112	86
(C) Total (Income from farming)	13361	10444	11965	12026	10919
Profit/loss= Output-Input	-2437	-250	-1371	-2810	1946

Source: Prepared by Authors, (2023) *Groundnut, sorghum, and Secale cereale (rye).

Note: Rs-ha-1

Table-2 shows the output cost of the different crops per hectare. After the cultivation of crops, the main output of crops is used in the form of sale in the market and domestic storage in the home for the rest of the period. The maximum average sale of crops as an output in the market was black gram (Rs. 8824 per ha), and the minimum was sesame (Rs. 6414 per ha). In drought-prone regions, domestic food grain storage becomes very important for livelihood—the maximum domestic storage of crops as output was wheat (Rs. 7323 per ha). Wheat had a high monetary value in the form of domestic storage due to its use as the primary bread in every household in the region, regardless of income capability. The agricultural residues are mainly post-harvest remains, and they can be used in agriculture processes because of their organic matter, nutrients, hollow structure, etc. They can help in replanting crops in the soil, increasing soil moisture content, decreasing bulk density, and increasing total porosity and aggregate stability. The average output of residue or straw as a monetary value was maximum in black gram (Rs. 294 per ha) and minimum in mustard (Rs. 74 per ha) through selling for other purposes. The average annual output of different crops per hectare in the Bundelkhand region. The monetary value of the average output of mustard (Rs. 10444 per ha) was comparatively lower than that of other prominent crops in the area, such as black gram (Rs. 13361 per ha), wheat (Rs. 12026 per ha), sesame (Rs. 11965 per ha), and other crops (Rs. 10919 per ha) in the study area (Table 2). The input-output analysis of individual crops exhibits significant variability due to many factors influencing regional agricultural practices. These factors encompass a range of elements, including the utilisation of diverse seed varieties, the availability of fertilisers, challenges related to water scarcity, soil infertility resulting from rocky terrain and soil erosion, fragmented land distribution, inadequate irrigation facilities, limited adoption of modern farming techniques, reliance on culturally ingrained traditional farming methods, and obstacles about market accessibility for the sale of crop outputs. These factors substantially impact the sustainability of livelihood sources within the region.

The outcomes of crop cultivation often present unfavourable circumstances for rural farmers, as agricultural activities frequently result in consistent financial losses, engendering livelihood challenges within their communities. An in-depth input-output analysis of major crops such as wheat, black gram, sesame, and mustard reveals that farmers are experiencing capital losses in their agricultural endeavours. Intriguingly, excluding the cost of human labour from the total input expenses would render the outcomes of these crops profitable. Notably, among various other crop groups, including black gram split (urad), groundnut (mufali), sorghum (jowar), and Secale cereals (rye), profitability is observed when human labour costs are factored into the total input expenses. The prevalent illiteracy among farmers in the region, coupled with apprehensions regarding loans and paperwork, often leads them to seek high-interest loans from local moneylenders. In the aftermath of agricultural failures, farmers frequently resort to migration and, tragically, instances of suicide due to the loss of social support and heightened economic burdens within their villages. While crop insurance schemes like the Pradhan Mantri Fasal Bima Yojana aim to enhance crop productivity in the country, challenges persist in their practical implementation at the grassroots level, limiting their benefits for farmers. These multifaceted factors collectively contribute to diminishing agricultural productivity, placing farmers under significant stress and prompting migration to urban areas for improved livelihood opportunities.

Impact on Livelihood

Agricultural productivity plays a fundamental role in shaping the socio-economic conditions of farmers in underdeveloped rural areas. A meticulous examination of agricultural inputs and outputs has shown that the livelihood conditions reliant on agriculture in this study area are distressing, leading to precarious living conditions due to the uncertainty surrounding livelihood sources. This dire situation has consequently triggered a notable outflow of migrants from the Bundelkhand region. Research Findings suggest that a low average annual household income characterises the region, heightened vulnerability to the impacts of climate change, and limited access to resources (Sah et al., 2021; Singh & Singh, 2019). Farmers in Bundelkhand perceive climate change as a palpable threat, compelling them to make critical decisions regarding adaptation to mitigate its adverse effects. Moreover, issues such as agricultural indebtedness, distress migration, and constraints in dairy farming practices further compound the challenges livelihoods face in this region (Anuja, 2018). As farmers enhance their agricultural productivity over time, agriculture can become a transformative force for long-term livelihood improvements. This transformation can manifest through various avenues, including the generation of increased employment opportunities, the diversification of food sources, the facilitation of capital formation through demand-driven food exports, the expansion of the market size and job opportunities by augmenting labour demands, the establishment of business-oriented infrastructure, and advancements in food processing capabilities. These direct and indirect developments play a pivotal role in mitigating social and economic disparities while contributing to the enhancement of rural welfare through the progressive evolution of livelihood sources.

Constraints in Agricultural

Agricultural development has been inadequate throughout history for sustainable livelihood. Several constraints prevent agrarian development and its positive outcomes from reaching the region's people. Significant issues like extreme weather, geological disasters, residents' perspectives, and many types of literature provide insights into the barriers preventing the agricultural growth of the Bundelkhand region. The agricultural sector in the region is profoundly affected by irregular rainfall patterns and insufficient water conservation practices, leading to increased input expenses and reduced food grain output. Specifically, Tudar village encounters a shortage of irrigation resources, with only two wells catering to approximately 100 households, and on-site observations indicate that these sources are utilised for irrigation and domestic water consumption, similar to Nayagaon village. Consequently, there is a heavy dependence on monsoons for agricultural operations. Water scarcity is compounded by various factors, including hard rock impeding water penetration, elevated evaporation rates, and a depleted groundwater level, all of which significantly impede agricultural productivity and contribute to instances of farmer suicides. The allocation of limited water resources in villages reflects a feudalistic mindset characterised by arrogance, discrimination based on caste and class, and a negative impact on both human health and agricultural activities. The quality and quantity of water are compromised by the attitudes of upper caste and class individuals, leading to a decline in agricultural output. Small-scale farmers from marginalised caste and class backgrounds bear the brunt of this discrimination, directly and indirectly affecting agricultural productivity and livelihoods in the region. Moreover, the reliance on traditional tools over modern machinery and limited technological information diffusion in Tidani and Maheba villages hampers agrarian productivity and sustainability. Challenges in implementing agricultural schemes due to lack of awareness, corruption, and incompetence within the implementing agency further affect farmers' income and regional well-being. Additionally, the absence of land consolidation in Mukarwa village poses a significant obstacle to agricultural productivity, hindering the development of favourable livelihood conditions.

Strategies to Mitigate the Challenges

To tackle the obstacles encountered by agricultural livelihoods in the Bundelkhand region, adaptation and resilience strategies must be prioritised to address adverse agricultural conditions. The region's vulnerability underscores the imperative of implementing mitigation measures to protect agricultural production and livelihoods. Adopting sustainable agricultural practices and integrating modern equipment and techniques holds promise in establishing a more resilient ecosystem for livelihoods centred around agrarian activities within the research area. Livelihood diversification emerges as a critical strategy to enhance resilience, with smallholders often diversifying into off-farm activities like wage labour or small business ownership to cope with environmental stress. Additionally, agricultural diversification significantly improves resilience to climate change, offering various strategies to mitigate its impacts (Ghosh, 2019). Moreover, adopting climate-smart agriculture practices can enhance the region's agricultural productivity and food security (Sheppard et al., 2020). Improved agricultural practices, livelihood diversification, and risk mitigation measures are essential components of climate-smart agriculture that can achieve sustainable agricultural growth and enhance household livelihoods. Furthermore, incorporating agroforestry practices can serve as a sustainable response to climate change, buffering the impacts on agricultural production systems and rural livelihoods.

Conclusion

The analysis of agricultural inputs and outputs reflects the outcomes of agriculture in a region, influenced significantly by the physical environment and impacting agricultural practices and demographic profiles. Despite set objectives, agricultural schemes still need to meet the desired success, leaving farmers facing challenges in securing sustainable livelihoods and residing in distressing social and economic conditions. Low agrarian productivity drives rural-to-urban migration, with migrant remittances crucial for village families. To address these issues, enhancing equity, access, and affordability of education and healthcare services is essential for promoting healthy living and raising awareness about individual rights. Education plays a crucial role in combating discrimination based on caste and class, contributing to eradicating feudalistic mindsets. Initiatives like afforestation and adopting scientific agricultural practices are needed to mitigate the adverse impacts of shifting monsoon patterns and altering soil profiles. Fostering a scientific attitude among the populace can enhance agricultural productivity through advanced input equipment utilisation. Establishing more financial institutions, combating corruption, and improving government officials' efficiency in implementing agricultural schemes are vital for creating a sustainable agricultural environment supporting enduring rural livelihoods.

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TRADE AGREEMENTS AND GLOBAL SUPPLY CHAINS: ANALYZING INFLUENCE ON DYNAMICS AND RESILIENCE

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Abstract

The globalization of trade has resulted in complex global supply chains that are intricately linked to international trade agreements. This paper investigates the role of trade agreements in shaping supply chain dynamics and resilience, especially in light of recent disruptions such as the COVID-19 pandemic and geopolitical tensions. Through a comparative analysis of major trade agreements—such as the USMCA, EU-Mercosur, and RCEP—this study examines how these agreements influence trade flows, regulatory standards, and supply chain strategies. The research emphasizes the dual nature of trade agreements: while they can enhance efficiency and lower costs, they can also lead to vulnerabilities in times of crisis. By analyzing data from various databases, including the World Trade Organization (WTO) and the United Nations Conference on Trade and Development (UNCTAD), this paper presents insights into how firms adapt their supply chains in response to the regulatory environments created by these agreements. The findings highlight the necessity for businesses to incorporate flexibility and risk management strategies within their supply chains to navigate the complexities introduced by trade agreements effectively.

Introduction

Global supply chains have become a cornerstone of international trade, enabling the efficient movement of goods and services across borders. Trade agreements play a pivotal role in facilitating these supply chains by establishing the regulatory framework within which trade occurs. This paper explores the intricate relationship between trade agreements and global supply chains, focusing on how these agreements affect supply chain resilience and responsiveness to disruptions. The significance of understanding this relationship is underscored by recent global challenges that have exposed vulnerabilities in supply chains, prompting businesses and policymakers to rethink traditional approaches to trade and logistics.

Study Region

This study focuses on three major trade agreements: the United States-Mexico-Canada Agreement (USMCA), the European Union-Mercosur Agreement, and the Regional Comprehensive Economic Partnership (RCEP). Each of these agreements represents diverse economic contexts and regulatory environments, offering valuable insights into how trade policies shape supply chain operations in different regions.

Objectives

(1) To analyse the impact of trade agreements on the flow of goods and services within global supply chains.
(2) To assess how trade agreements affect regulatory standards and compliance requirements for businesses.
(3) To evaluate the resilience of supply chains in the face of disruptions and the role of trade agreements in mitigating risks.
(4) To identify best practices for businesses in adapting their supply chain strategies to align with trade agreements.

Database and Methodology

This research employs a mixed-methods approach, utilizing quantitative and qualitative data. Key databases include, namely, World Trade Organization (WTO) statistics, UNCTAD trade data and International Monetary Fund (IMF) reports. Quantitative analysis will involve econometric modelling to assess trade flows and supply chain metrics before and after the implementation of selected trade agreements.

USMCA: Enhancing Regional Integration

The United States-Mexico-Canada Agreement (USMCA) replaced NAFTA and aimed to enhance regional trade by incorporating stricter rules of origin, labour provisions, and environmental standards. These policies have had a profound impact on supply chains in the following ways:

(a) Rules of Origin: USMCA requires that 75% of a vehicle's components be manufactured in North America (up from 62.5% under NAFTA). This policy encourages companies to source materials locally, fostering regional supply chains. According to a 2022 study by the Peterson Institute for International Economics, this could increase North American vehicle production by $34 billion annually.

(b) **Labor and Environmental Standards:** The agreement promotes higher labour standards and environmental protections. Companies may need to invest in compliance mechanisms, affecting operational costs but potentially leading to more sustainable practices. For example, new labour provisions are projected to raise wages in Mexico, impacting labour cost dynamics in the region.

(c) **COVID-19 Response:** The pandemic underscored the importance of regional supply chains. Disruptions in Asian supply chains prompted many firms to shift to North America for production. A survey by the Reshoring Initiative reported a 50% increase in companies considering reshoring to the U.S. as a direct response to the pandemic.

EU-Mercosur: Bridging Continents

The EU-Mercosur Agreement, linking the European Union and the South American Mercosur bloc, aims to reduce tariffs and foster cooperation. Its implications for supply chains include:

(a) **Tariff Reductions:** The agreement proposes to cut tariffs on 90% of goods traded between the EU and Mercosur. This reduction can streamline supply chains by lowering costs for European manufacturers sourcing raw materials from South America. For instance, EU exports to Mercosur could rise by €4.4 billion annually, boosting trade flow and investment.

(b) **Sustainability Focus:** The agreement incorporates commitments to sustainable development. This encourages businesses to align their supply chains with environmental goals, as seen in the increasing demand for sustainable products in Europe. A report from McKinsey indicated that consumers are willing to pay up to 25% more for sustainably produced goods.

(c) **Geopolitical Context:** The EU-Mercosur Agreement faces challenges due to concerns over deforestation in Brazil. Such geopolitical tensions can create uncertainty in supply chain planning, with companies needing to navigate risks associated with regulatory changes and public perception.

RCEP: A Regional Powerhouse

The Regional Comprehensive Economic Partnership (RCEP) is a significant trade agreement involving 15 Asia-Pacific countries. Its influence on supply chains is noteworthy:

(a) **Market Access:** RCEP provides preferential market access among member countries, facilitating trade flows. The agreement is expected to increase GDP in member countries by 0.2% annually, according to the Asian Development Bank. This can encourage investment in supply chain infrastructure.

(b) E-Commerce Provisions: RCEP includes provisions for digital trade, allowing for smoother cross-border data flows and reducing barriers for e-commerce. This is crucial as online trade surged during the pandemic, with e-commerce in Asia growing by 23% in 2020, according to UNCTAD.

(c) Diversification of Supply Chains: The agreement promotes diversification by reducing dependency on single markets, particularly important during the pandemic when disruptions affected specific regions. Companies can leverage RCEP to establish more resilient supply chains by sourcing inputs from multiple member countries.

The COVID-19 pandemic had profound effects on global supply chains, particularly within major trade blocs like USMCA, EU-Mercosur, and RCEP. Here's a detailed look at how the pandemic altered supply chain dynamics in these areas:

USMCA

(a) Disruption of Manufacturing: Lockdowns and health protocols led to temporary factory closures in the U.S., Canada, and Mexico. The auto industry, heavily integrated across these countries, faced significant production halts. According to the Automotive Policy Research Centre, vehicle production in North America dropped by over 30% in the early months of the pandemic.

(b) Shift to Regional Sourcing: Many companies began reconsidering their supply chain strategies, leading to a trend towards reshoring or nearshoring. A survey by the Reshoring Initiative indicated that 69% of manufacturers were planning to move some operations back to North America, driven by the need for supply chain resilience.

(c) Increased Focus on Flexibility: Businesses recognized the importance of having flexible supply chains. The pandemic underscored the vulnerabilities associated with over-reliance on distant suppliers, prompting a shift toward more localized sourcing to reduce risks.

EU-Mercosur

(a) Impact on Trade Flow: The pandemic initially disrupted trade flows, with EU exports to Mercosur falling by approximately 20% in 2020. The agriculture sector faced challenges as demand fluctuated and transportation logistics were disrupted.

(b) **Sustainability and Resilience:** The pandemic heightened awareness of sustainability in supply chains. Companies began prioritizing sustainable sourcing practices, aligning with the goals of the EU-Mercosur Agreement. The European Commission reported a rise in demand for sustainably sourced products, indicating a potential shift in consumer behaviour.

(c) **Geopolitical Tensions:** The pandemic exacerbated existing geopolitical tensions, particularly regarding environmental concerns in Brazil. This affected negotiations and trade relations, as European consumers and governments became more vocal about sustainability practices.

RCEP

(a) **Supply Chain Fragmentation:** The pandemic revealed vulnerabilities in the interconnected supply chains within RCEP member countries. Disruptions in one country (e.g., factory shutdowns in China) had ripple effects across the region, affecting production and delivery times.

(b) **E-Commerce Surge:** RCEP member countries saw a significant rise in e-commerce during the pandemic, with online retail growing by approximately 23% in 2020, according to UNCTAD. This shift necessitated adaptations in logistics and fulfilment strategies.

(c) **Increased Cooperation:** The pandemic encouraged member countries to enhance cooperation and streamline trade regulations. The RCEP agreement included provisions aimed at facilitating trade in times of crisis, potentially leading to a more resilient framework for future disruptions.

Here are some key data facts regarding supply chains and trade in the USMCA, EU-Mercosur, and RCEP blocs, comparing pre- and post-pandemic scenarios:

USMCA

(a) Manufacturing Output

- Pre-Pandemic (2019): North American vehicle production reached about 17 million units.
- Post-Pandemic (2021): Production fell to approximately 12 million units in the wake of the pandemic, reflecting a decrease of over 30%.

(b) Reshoring Trends:

- Pre-Pandemic: About 29% of U.S. manufacturers were considering reshoring.
- Post-Pandemic (2021): This figure rose to 69%, indicating a significant shift in strategy towards local sourcing.

EU-Mercosur

(a) Trade Flow

- Pre-Pandemic (2019): EU exports to Mercosur amounted to around €40 billion.
- Post-Pandemic (2020): Exports dropped by approximately 20%, totaling about €32 billion due to supply chain disruptions.

(b) Sustainability Awareness:

- Pre-Pandemic: Approximately 55% of European consumers indicated a willingness to pay more for sustainably sourced products.
- Post-Pandemic (2021): This willingness increased to around 75%, highlighting a growing demand for sustainability.

RCEP

(a) E-Commerce Growth:

- Pre-Pandemic (2019): E-commerce in Asia was valued at around $1.5 trillion.
- Post-Pandemic (2020): This figure surged to $2.8 trillion, reflecting a growth rate of approximately 87% as consumers turned to online shopping during lockdowns.

(b) Trade Volume:

- Pre-Pandemic (2019): Intra-RCEP trade was valued at about $10.5 trillion.
- Post-Pandemic (2021): Trade volume rebounded to approximately $11.5 trillion, indicating a recovery and renewed integration within the region.

The data illustrates significant shifts in supply chain dynamics and trade flows as a result of the COVID-19 pandemic. Companies in the USMCA region increased their focus on reshoring, while EU-Mercosur experienced a notable drop in trade, with a subsequent rise in sustainability awareness. In RCEP, e-commerce saw dramatic growth, underscoring a shift in consumer behaviour. These trends reflect broader changes in how businesses approach supply chains in a post-pandemic world. Trade agreements play a crucial role in shaping global supply chain dynamics, influencing everything from trade flows to regulatory compliance. Here's a deeper exploration of their effects, complexities, and the necessary strategies for businesses, alongside policy suggestions for enhancing supply chain resilience.

(1) The Influence of Trade Agreements on Supply Chains

(a) Efficiency and Cost-Effectiveness

- **Reduced Tariffs:** Trade agreements often lower tariffs and other trade barriers, allowing businesses to access cheaper raw materials and components from member countries. For instance, the USMCA's provisions have enabled U.S. manufacturers to source materials more cost-effectively from Mexico and Canada.
- **Streamlined Customs Processes:** Many agreements introduce measures to simplify customs procedures, reducing delays and associated costs in cross-border trade. For example, RCEP aims to harmonize customs procedures among member countries, promoting smoother trade flows.

(b) New Complexities and Vulnerabilities

- **Regulatory Compliance:** Different regulatory standards can complicate compliance for businesses operating in multiple jurisdictions. Companies may need to invest in understanding and meeting various standards, such as labour laws and environmental regulations.
- **Supply Chain Disruption Risks:** While trade agreements enhance connectivity, they can also create vulnerabilities. For example, over-reliance on a single trade partner can expose firms to risks, as seen during the COVID-19 pandemic when many supply chains were severely disrupted.

(2) Flexible Supply Chain Strategies

To navigate the complexities introduced by trade agreements, firms should adopt flexible supply chain strategies that include:

(a) Diversification of Suppliers: Multiple Sourcing: Businesses should identify and engage multiple suppliers across different regions. This strategy reduces dependence on a single source and mitigates risks related to regional disruptions.

(b) Local and Regional Sourcing: Regional Supply Chains: Companies should consider regional sourcing within trade blocs (e.g., sourcing from neighbouring countries in the EU-Mercosur agreement) to leverage trade benefits and reduce transportation risks and costs.

(c) **Investment in Technology:** Supply Chain Visibility: Utilizing technologies like blockchain and IoT can enhance visibility across supply chains, allowing firms to track products and respond quickly to disruptions or regulatory changes.

(3) Robust Risk Management Practices

(a) **Risk Assessment Frameworks:** Continuous Risk Assessment: Firms should implement ongoing risk assessment frameworks that evaluate potential disruptions and regulatory changes. This proactive approach enables businesses to develop contingency plans.

(b) **Scenario Planning:** Flexibility in Operations: Businesses should engage in scenario planning to prepare for various potential disruptions (e.g., geopolitical tensions, pandemics). This involves identifying critical supply chain dependencies and creating response strategies.

(c) **Collaboration with Stakeholders:** Engaging with Partners: Collaborating with suppliers, customers, and logistics providers can foster a more resilient supply chain. Sharing information and resources helps all parties respond effectively to changes.

(4) Policy Suggestions for Enhancing Supply Chain Resilience

(a) **Support for Small and Medium Enterprises (SMEs):** Capacity Building: Governments should provide resources and training programs to help SMEs understand trade agreements and compliance requirements. This support will enable smaller businesses to adapt and thrive in a competitive environment.

(b) **Harmonization of Standards:** Regulatory Cooperation: Policymakers should work towards harmonizing standards across trade agreements to reduce complexity for businesses. This can involve aligning labour and environmental regulations to facilitate smoother compliance.

(c) **Investment in Infrastructure:** Enhancing Trade Facilitation: Governments should invest in infrastructure that supports trade, such as ports and logistics facilities. Improved infrastructure can reduce transit times and costs, enhancing overall supply chain efficiency.

(d) **Encouraging Sustainable Practices:** Incentives for Sustainability: Policymakers should create incentives for businesses to adopt sustainable practices in their supply chains. This could include tax breaks for companies that prioritize eco-friendly sourcing or invest in green logistics.

Conclusion

In conclusion, trade agreements significantly shape global supply chain dynamics, offering both opportunities for efficiency and complexities that businesses must navigate. While these agreements facilitate reduced tariffs and streamlined customs processes, they also introduce regulatory compliance challenges and vulnerabilities to supply chain disruptions. To effectively adapt, firms should implement flexible strategies, such as diversifying suppliers and investing in technology for enhanced supply chain visibility. Additionally, robust risk management practices, including ongoing risk assessments and scenario planning, are crucial for mitigating potential disruptions. Policymakers also have a critical role in this landscape; by supporting small and medium enterprises, harmonizing regulatory standards, investing in infrastructure, and encouraging sustainable practices, they can create an environment conducive to resilient supply chains. Future research should focus on the evolving nature of trade agreements and their implications for supply chain resilience, particularly in the context of geopolitical factors and technological advancements. By addressing these challenges and opportunities, both businesses and governments can better navigate the complexities of global trade, ultimately fostering a more resilient and efficient supply chain ecosystem. Future research should focus on:

(a) Evolving Trade Agreements: Investigating how emerging trends (e.g., digital trade, climate change) will shape future trade agreements and their implications for supply chains.
(b) Impact of Geopolitical Factors: Exploring the effects of geopolitical tensions on supply chain strategies and trade agreements, particularly in regions like Asia-Pacific.
(c) Technological Innovations: Assessing how technological advancements can enhance supply chain resilience in the context of evolving trade landscapes.

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HISTORICAL PARADIGM SHIFT IN TRANSPORTATION IN INDIA

Professor Madan Lal and Anjali

Abstract

The rapid and unique transition from human-powered bicycles, buses, and gasoline-powered to an aspirational all-electric vehicle system in India holds significant importance in the evolution of transportation technology. Analysing the rapid development of electric vehicles (EVs) in India sheds light on the critical technical, economic, social, political and environmental factors contributing to this transformation. This paper aims to analyse the electric vehicles history and identify the significant factors that have influenced the growth of the EV industry in India. This is done through a synthesis of literature and thematic-content review methodology. This provides valuable insights for policymakers in India and other countries, demonstrating how different factors in India played a crucial role in adopting EVs by shaping the regulatory environment, providing incentives and creating the necessary infrastructure.

Introduction

The transportation industry significantly releases greenhouse gas emissions, which have a significant environmental impact (Sioshansi & Webb, 2019). The automotive industry is scrutinised due to its substantial contribution to global carbon emissions released into the atmosphere (Bhaskar et al., 2019). Furthermore, internal combustion engine vehicles exhibit an efficiency of approximately 20%, dissipating the remaining energy as heat and emissions are directly released into the environment. As a result, researchers have felt the need to explore a change in perspective, mainly due to the volatile prices of fossil fuels and environmental concerns (Gielen et al., 2019). Electric vehicles have emerged as a groundbreaking transportation option in the automotive sector, prompting numerous research endeavours in this field (Abo-Khalil et al., 2022; Subramaniam et al., 2019). Electric vehicles offer a solution for achieving energy independence

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and reducing dependence on imported resources. India, being one of the leading exporters of crude oil globally, can significantly benefit from the adoption of EVs, which can contribute to the country's self-sustainability (Kalita et al., 2021). The emissions from automobiles, including carbon dioxide (CO2), are among the primary contributors to air pollution (Kalita et al., 2021). Therefore, EVs present a viable alternative for mitigating CO2 emissions (Doucette & McCulloch, 2011), thereby aiding in reducing air pollution, a critical issue faced by major metropolitan cities such as Delhi and Mumbai. To promote the adoption of EVs, governments have initiated financial policies. However, for these policies to be effectively implemented, decision-makers need to adopt a long-term perspective (Sierzchula et al., 2014; Zhang et al., 2014). Therefore, the transition to EVs in the Indian context holds various insights.

Study Region

This study focuses on tracing the historical development of electric vehicles (EVs) in India. It will explore the early conceptualisation and adoption of electric mobility within the country, beginning with the initial interest in sustainable transportation. The research will examine critical milestones in the evolution of electric vehicles, including government policies, technological advancements, and market dynamics that have shaped the sector. The study will also delve into India's role in global electric vehicle development, comparing it with trends in other countries. By identifying the social, economic, and environmental factors influencing the adoption of EVs, the research will provide a comprehensive timeline of how India has progressed from early experiments to more recent large-scale initiatives like the National Electric Mobility Mission Plan (NEMMP) and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme.

Objectives

The objective is to classify and present comprehensive phases of the historical evolution of E-mobility in India and to highlight the broad factors that impact the adoption of Electric Vehicles. The findings of this study will enhance the existing knowledge base on EVs, enabling manufacturers to prioritise the most influential factors.

Database and Methodology

The research design utilises a combination of literature review and content analysis techniques. The paper adopts a thematic-content review methodology by examining pertinent literature from databases like Google Scholar and Scopus. A comprehensive search was conducted, resulting in the selection of relevant papers. The abstracts of these papers were carefully examined, and papers were selected that were deemed appropriate for the study. These selected papers were then thoroughly read to identify significant themes aligned with the research objectives. The identified themes were developed conceptually, drawing upon existing literature in the field. The methodology is designed to systematically analyse existing knowledge, policies, technological advancements, and other historical aspects relevant to the development of electric vehicles in India. The first step of the research involved a comprehensive literature review. Relevant academic articles, government reports, industry publications, policy documents, and historical data on electric vehicles in India were gathered. This review helped identify the significant factors that have influenced the growth of the EV industry in India. It also provides context to frame the evolution of policies, technological advancements, and market forces shaping the electric vehicle sector. To further investigate the historical evolution of EVs in India, thematic-content analysis was used to evaluate the data collected through the literature review. Such analysis allows for a structured examination of textual data to identify patterns, themes, and trends relevant to the research topic. Data collection, coding, and systematic data analysis uncovered the critical drivers behind the introduction and growth of electric vehicles in India. The analysis focussed on identifying major historical turning points, the role of public and private stakeholders, and the influence of global trends on India's EV development.

Results and Discussion

The insights gained from the literature review and content analysis were synthesised to provide a straightforward narrative of the historical progression of electric vehicles in India. This synthesis highlights the evolution of policies, market dynamics, and technological developments, offering a comprehensive understanding of the historical background of electric vehicles in India. E-vehicles have gained popularity among Indian consumers due to their affordability and convenience, offering a cost-effective alternative and technological improvement (Mou N, 2017). Electric vehicles offer simplified operation, fewer mechanical components, and reduced heat generation (Noor et al., 2017). As renewable energy systems progress, the EV market will also witness substantial growth and development over time (Olabi et al., 2021) (Table-1).

Table-1: Automobile Production Trends in India

Category	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Passenger Vehicles	4,020,267	4,028,471	3,424,564	30,62,280	36,50,698	45,78,639
Commercial Vehicles	895,448	1,112,405	756,725	6,24,939	8,05,527	10,35,626
3- Wheelers	1022,181	1,268,833	1,132,982	6,14,613	7,58,669	8,55,696
2- Wheelers	23,154,838	24,499,777	21,032,927	18,349,941	1,78,21,111	1,94,59,009
Quadricycles	1,713	5,388	6,095	3,836	4,061	2,897
Grand Total	2,90,94,447	3,09,14,874	2,63,53,293	2,26,55,609	2,30,40,066	2,59,31,867

Source: https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=13

The Indian automobile market is divided into categories, as shown in Table-1. Analysis reveals that most vehicles belong to total passenger vehicles and two-wheelers. As a result, the EV market in India should focus on these specific vehicle segments to capture a significant market share (Kalita et al., n.d.). The history of EVs in India dates back to the 19th century, predating the introduction of the REVA electric car (Goel et al., 2021), which gained significant attention in the market. The history of electric vehicles (EVs) in India can be divided into several distinct phases:

Phase-1: The Advent of Electric Vehicles (1993): India's initial foray into EVs began with the introduction of the Lovebird, the first electric car manufactured by Eddy Current Controls.

Phase-2: The Initial Phase (1996-2000): In 1996, Scooter's India Pvt Ltd introduced India's inaugural electric three-wheeler, the Vikram Safa. However, the vehicles faced a significant drawback due to using lead-acid batteries. Moving ahead to 2000, BHEL developed India's first electric bus with the support of the Ministry of Non-Conventional Energy Sources. Around 200 of these buses were constructed and deployed in Delhi. Nonetheless, the bus encountered issues related to the high cost of batteries, short battery lifespan, and inadequate consistency in performance.

Phase-3: REVA (India’s first successful electric car, 2001): In 2001, RECC (Reva et Car Company) launched REVA, India's first successful electric car. 2009 Reva introduced Reva NXR and Reva NXG at the Frankfurt Motor Show. In 2010, Toyota introduced the 'Prius hybrid' model, and three years later, they released the Camry hybrid model (Goel et al., 2021) (Fig. 1).

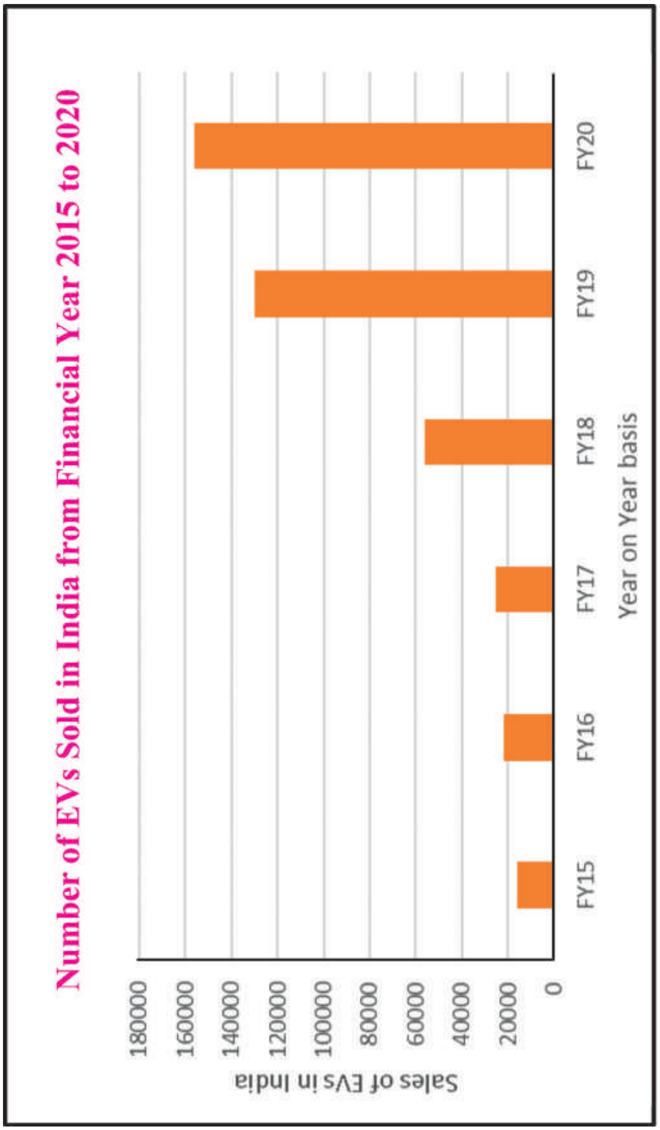

Number of EVs Sold in India from Financial Year 2015 to 2020
Sales of EVs in India
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
FY15
FY16
FY17
FY18
FY19
FY20
Year on Year basis

Fig. 1

Phase-4: EV Incentive Phase

(a) Initial Incentive Phase (2010-2013)

2010, the Indian government introduced its first significant scheme to encourage EVs. Financial incentives of up to 20 per cent on ex-factory vehicle prices were provided to EV manufacturers, and the Ministry of New and Renewable Energy (MNRE) approved a Rs 95-crore scheme (Muduli, n.d.).

(b) National Electric Mobility Mission Plan (2013)

In 2013, the Indian government launched the National Electric Mobility Mission Plan (NEMMP) to put 7 million EVs on the road by 2020 (National Electric Mobility Mission Plan, n.d.).

(c) FAME India Phase I (2015-2019)

Union Budget for 2015-16, unveiled the Faster Adoption and Manufacturing of Electric Vehicles (FAME) initiative, allocating an initial budget of Rs 75 crore towards its implementation (Press Information Bureau, n.d.). The focus was on reducing the upfront cost of EVs and establishing charging infrastructure. This phase witnessed a gradual increase in the sales of electric two-wheelers and some initial deployments of electric buses. In 2017, India expressed the country's ambition to 30% transition to electric cars by 2030, indicating a strong commitment towards adopting a fully electric vehicle fleet.

(d) FAME India Phase II (2019-2024)

The FAME-II schemes, a program with a budget of Rs 10,000 crore, were approved by the Union Cabinet in February 2019. They emphasised the electrification of public and shared transportation, including buses, three-wheelers, and taxis.

Reasons for growth of EV Industry in India

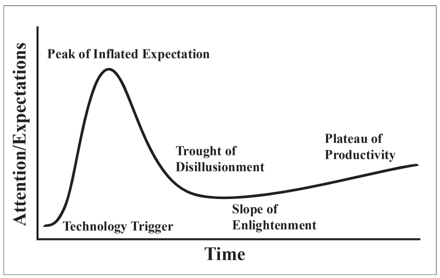
The adoption of EVs is influenced by several critical factors, including government financial incentives, industry growth, and market demand patterns (Hertzke et al., 2018). The Indian government is providing substantial support to promote the advancement of EVs in India (Dixit & Singh, 2022). By focusing on factors like technical, economic, social, political and environmental aspects (Table-2), India can develop a comprehensive approach to promote the adoption of EVs and other sustainable forms of transportation (Ali & Naushad, 2022).

Table-2: Reasons for growth of EV Industry in India

Key Themes Identified	Sub-Themes Identified	Brief	Reference Support
Technological Factors	Technology Advancement	The battery represents a significant cost component for EVs, but technological advancements have contributed to cost reduction, ultimately making EVs more affordable. As a result, customers are likely to embrace EVs at a faster pace.	(Ogura & Kolhe, 2017)
	Research and Development	Research in battery manufacturing, bi-directional charging, and battery life funded by the government encourage greater adoption of EVs.	(Ajanovic & Haas, 2016; Vidhi & Shrivastava, 2018)
	Availability of Charging Stations	The presence of a charging infrastructure is of utmost importance for EV owners. The availability of charging infrastructure significantly boosts customer confidence and encourages them to purchase EVs. However, the charging infrastructure in India is still in its early stages, and it plays a vital role in the adoption of EVs.	(Adepetu et al., 2016; Caperello & Kurani, 2012; Illmann & Kluge, 2020; Javid & Nejat, 2017)
Economic Factors	Rising Income Level	The economic climate improved, resulting in higher incomes for urban households and a larger share of their budgets being allocated towards transportation expenses. This led to an increase in the growth of EVs. Also, electricity consumption and real income positively impact pollutant emissions.	(Akadiri et al., 2019; Weinert et al., 2007)

	Electric Vehicle price	The cost of EVs significantly influences automobile buyers' purchasing decisions. Customers are naturally drawn to affordable products that offer potential cost savings. Lifecycle cost analysis demonstrates that BEVs have lower ownership costs than ICVs, making them more cost-effective.	(Ali & Naushad, 2022; Turrentine & Kurani, 2007)
	High Fuel and Energy Cost	The growth of EVs is influenced by anticipation of future increases in gasoline prices. When they anticipate a rise in gasoline prices, owners of hybrid vehicles tend to lean towards alternative green vehicles.	(Sims Gallagher et al., 2008)
	Financial incentives and tax benefits	It was found that implementing environmentally sensitive taxes and subsidies positively impacts the entailment of a net-zero pipeline. Monetary incentives like tax deductions, toll exemptions, accessible parking facilities, and free access to charging stations can help. The government is implementing subsidies and tax benefits for buyers to encourage the widespread adoption of EVs in India.	(Ajanovic & Haas, 2015; Kalita et al., n.d.; Saint Akadiri et al., 2020; Sierzchula et al., 2014)
Political Factors	Regulatory Frameworks	A framework must involve three key stakeholders, the government, consumers, and producers, to examine the relationship between adopting environmentally friendly technologies and the resulting social benefits. In India, both the central and state governments are actively formulating policies and regulatory frameworks to foster the adoption of EVs throughout the country.	(Huang et al., 2018; Mishra et al., 2021)

	Legislating standards	The research emphasised the importance of establishing regulatory standards for charging EVs. Loose IP protection made it easier for new companies to enter the industry, leading to increased competition and lower prices.	(Martínez-Lao et al., 2017; Weinert et al., 2007)
	Other non-monetary measures	Access to bus lanes, flexible and shorter charging options, permission to enter city centres, and establishing zero-emission zones can go a long way. The City of Rotterdam is an excellent example of promoting green energy use in vehicles through policies such as CO_2-based fuel and registration taxes.	(Ajanovic & Haas, 2015)
Social Factors	Behavioral Changes	There is a greater participation in the worldwide movement towards de-carbonization. Achieving 100% adoption of EVs will require several human behavioural changes.	(Saint Akadiri et al., 2020; Vidhi & Shrivastava, 2018)
	Hype	Technological hype can positively influence public policy and private funding for R&D efforts, attracting sponsors for technology development and better serving the development of sustainable mobility. Gartner Hype Cycle can be quoted here.	(Bakker, 2010)



	Social Environment	The social aspect is crucial in indirectly influencing consumer adoption of EVs. Psychological elements, including cost perception, perceived benefits, attitudes towards new technologies, and social influence, all contribute to consumer decision-making. Consumers' attitudes significantly impact their decision to invest in EVs, particularly regarding their perception of new technologies.	(Hidrue et al., 2011; Steinhilber et al., 2013; Q. Zhang et al., 2018)
Environmental Factors	Environmental Concern	India faces significant challenges in terms of air pollution and congestion in urban areas. With growing environmental concerns, customers are increasingly willing to embrace EVs. Individuals who are environmentally conscious and seek fuel cost savings are more inclined to purchase EVs	(Pierre et al., 2011; Schuitema et al., 2013)

Source: Authors' Analysis

Conclusion

Electric vehicles only make up 0.29% of total registrations in India. Achieving 30% electrification in vehicles requires a two-pronged strategy. Firstly, India needs to establish the appropriate infrastructure and technology to support the manufacturing of EVs. Secondly, provisions should be introduced to enable the conversion of existing vehicles into hybrid EVs through retrofitting, aiming to reduce pollution levels. The government must develop market-friendly policies and customer-centric approaches to promote widespread adoption among potential customers. This includes establishing a flexible regulatory framework, offering tax advantages, and providing various financial incentives.

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OCCUPATIONAL DIVERSIFICATION AND NON-FARM EMPLOYMENT IN RURAL WEST BENGAL (2001 TO 2011): A DISTRICT LEVEL ANALYSIS

Dr. Paramita Roychowdhury

Abstract

Rural workforce in India depends mainly on agriculture, in spite of several attempts to diversify them towards non-agricultural sectors. Given the persisting rural poverty and immense employment pressure on agricultural land, occupational diversification and increase in rural non-farm employment are considered as two critical ways to improve the rural livelihood in India. In this context, the paper attempts to identify the pattern of change in structure of rural workforce in West Bengal, one of the agriculturally prosperous states in India. The paper also attempts to identify the district wise variation of composition of rural main and marginal workforce in West Bengal for the years 2001 and 2011. Moreover, the paper attempts to examine the district wise variation of diversification of rural workforce using Simpson Index. Based on data obtained from Census of India (2001 and 2011), it has been observed that share of main rural workers to total rural workers has declined in West Bengal during this period. The share of agricultural workers has increased during this study period as a result of significant rise in agricultural labourers in spite of decline in the share of cultivators in the state. The diversification of the rural workforce has also reduced during 2001-2011 in West Bengal.

1ntroduction

Rural workforce in India has remained predominantly agricultural in nature over the years (Mahendra Dev, 1990 and 2017; Srivastava & Srivastava, 2010). Fluctuations in agricultural wages and nominal decline in rural poverty for majority of this workforce have also been observed (Lanjouw & Kijima, 2005; Lanjouw & Murgai, 2009; Ghosh, 1998) in spite of substantial progress in agriculture during green revolution phase and thereafter. Birthal (2019) opined that India has experienced significant increase in agricultural productivity and subsequent decline in rural poverty owing to the technological breakthrough in the agriculture.

He also stated that no significant rise in the income level of the farmers, particularly of the small and marginal farmers, moreover, 50% of them have a covert desire of leaving agricultural sector for better employment opportunities. According to Mehrotra and Parida (2019), the employment crisis in India has resulted from the rising level of education and aspirations of the youth for working in the non-farm sector. From the periodic labour force survey of NSS (2005, 2011-12 and 2017-18), they have concluded that decline in total employment in India is evident, particularly during the last two rounds. Besides, a substantial diversification of rural workforce from farm to non-farm has not been observed (Chand et.al., 2018). The transformation of workforce from agriculture to non-agriculture sector, in whatever extent has occurred, is mainly attributed to the diminishing returns of land and labour productivity and gradual mechanization of agriculture (Dutta & Ghosal, 2014 & 2015). Therefore, from policy perspectives, diversification of workforce from agriculture to non-agricultural sector have remained as great challenges in India. In this context, the present study attempts to analyse the pattern of workforce diversification and non-farm employment in West Bengal, one of the agriculturally prosperous states in India, during 2001-2011. Based on the Census of India estimates, this study attempts to examine the district wise composition of main and marginal workers in West Bengal. This study also aims in analyzing the inter-district variations of occupational diversification in West Bengal, during 2001 to 2011.

Study Region

West Bengal, which was one of the leading industrially developed states during post-independence era, has experienced a gradual decline of the industrial sector. In comparison, agriculture sector in this state performed better particularly after successful implementation of land reforms and subsequent changes in the rural institutions during 1980s. West Bengal achieved leading position among Indian states in production of food grains, potato and oilseeds (West Bengal Development Report, 2010) and continues with this position. During 1990s, agricultural distress that was observed all over India also prevailed in West Bengal (Dutta & Ghosal, 2014 & 2015). Increasing population pressure on agricultural land, rising cost of agricultural inputs, withdrawn of subsidies and the public sector investment in agriculture were the key factors for making agriculture as a less profitable job (West Bengal Development Report, 2010). After the introduction of the structural adjustment programme, rural poverty in West Bengal increased immediately and decreased thereafter (Ghosh, 1998; West Bengal Development Report, 2010). According to the latest estimates of Planning Commission, Government of India (2014), 22.5% (141.10 lakhs persons) population in rural West Bengal live below poverty line even after a gradual decline in rural poverty during 2004-05 to 2011-12. In spite of persisting poverty in rural West Bengal, total rural agricultural workforce increased from 58.60 % in 2001 to 61.44 % in 2011 indicating non-farm employment did not substantially increase in rural West Bengal. According to Census of India (2011), West Bengal is the fourth largest state in terms of total population (after Uttar Pradesh, Maharashtra and Bihar) and second most densely populated state (after Bihar) in India. Sharing approximately eight per cent of the total population of India and very high density of population (1029 persons/sq. km. in 2011), West Bengal presents a case of immense population pressure on land. As (organized) manufacturing sector has been gradually declining both in terms of share of GDP and employment (West Bengal Human Development Report, 2004), agriculture has remained as the main source of employment in West Bengal.

Objectives

(1) To analyze the district-wise composition of rural main and rural marginal workers in West Bengal in 2001 and 2011

(2) To examine the nature of district-wise diversification of rural main worker and rural marginal workers in West Bengal in 2001 and 2011

Database and Methodology

This study is based on the data collected from Primary Census Abstract of West Bengal, 2001 and 2011 published by Census of India. All the definitions used in this study follow Census of India. Workers have been divided into two categories i.e. main and marginal workers and further classified as cultivator, agricultural labourer, household industry worker and other worker (Census of India, 2011). Planning Commission, Government of India estimates on poverty for different periods have also been used in this study. Maps have been prepared based on the Census Atlas of West Bengal (2001 & 2011). To analyze the diversification of rural workers, Simpson Index (S.I.) for diversification (as cited in Khatun & Roy, 2012; p116) has been used.

$$S.I. = 1 - \sum_{1}^{N} P_i^2$$

Here, N is the total number of classes of the rural workers and Pi is the share of workers in ith class. The Simpson Index varies from 0 to 1, indicating '0' for complete specialization in favour of a particular occupational category and '1' for complete diversification. Therefore, if the workers are divided into four categories, considering each category has equal share of workers, the S.I. value will be 0.750 i.e. maximum diversification. In this study, the value of S.I. varies from 0 to 0.750.

Results and Discussion

According to Census of India, 2001 and 2011, total work participation rate (WPR) of West Bengal has increased from 36.77% to 38.08% and rural work participation rate from 37.90% to 38.73%. The WPR for the rural main workers has been observed as 27.89% and marginal workers as 10.01% in 2001. The rural main WPR has decreased to 26.52% and rural marginal WPR has increased to 12.21% in 2011. The composition of the rural workforce has also changed during this period, with share of main workers to total workforce declined by 5.11% and consequent rise in the share of marginal workers in West Bengal. Considering the district wise distribution of rural main and marginal workers, it has been observed that the share of main workers to total workers have declined from 2001 to 2011 in all the districts except Uttar Dinajpur and Koch Bihar (Fig. 1). The highest decline in the percentage of main workers has been observed in South Twenty-Four Parganas district followed by Puruliya and Darjiling. In 2011, the percentage of marginal workers has outnumbered the percentage of main workers in 2011 (Fig. 1). Moreover, it needs to be mentioned that in Maldah, Birbhum, Bankura, South Twenty-Four Parganas and Purba and Paschim Medinipur districts, more than one third of the workforce have been reported as marginal workers in 2011 (Fig. 2). The composition of rural main and marginal workers during 2001-2011 has also changed. In 2001 the agricultural workforce in rural West Bengal was 87,78,365 persons and increased to 1,47,96,359 persons in 2011. Among the agricultural workers, cultivators both main and marginal have declined in absolute number and also percentage share to the total workers. The main and marginal agricultural labourers in contrast have increased in absolute number as well as percentage share to the total workers. However, considering the composition of main workers, it is evident that share of cultivators to the total main workers have declined in all the districts in West Bengal except district Haora (Fig. 1). The decline in terms of percentage share of cultivators has been maximum in Puruliya district followed by Bankura. The rise in the share of main agricultural labourers has been maximum in Birbhum district followed by Nadia.

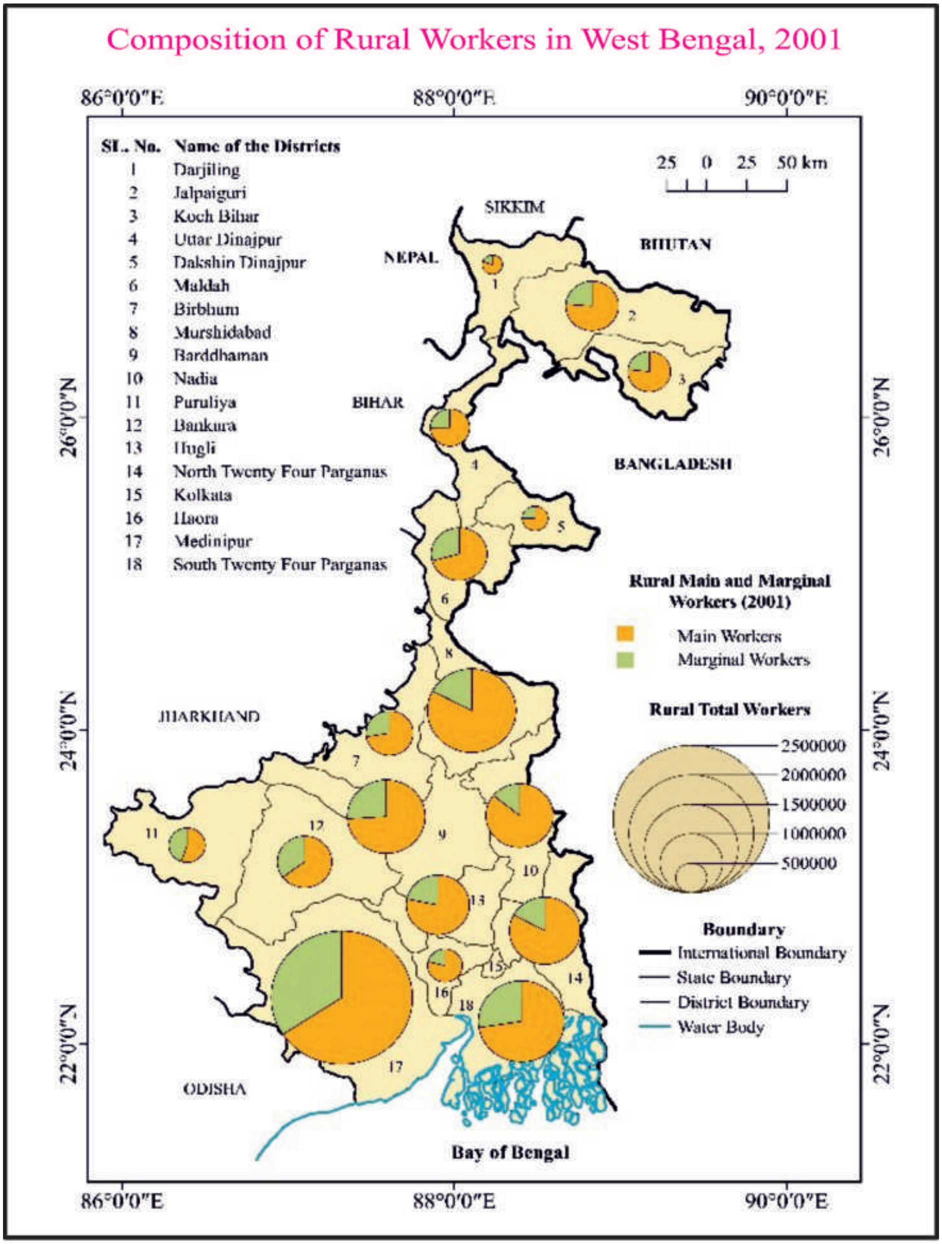
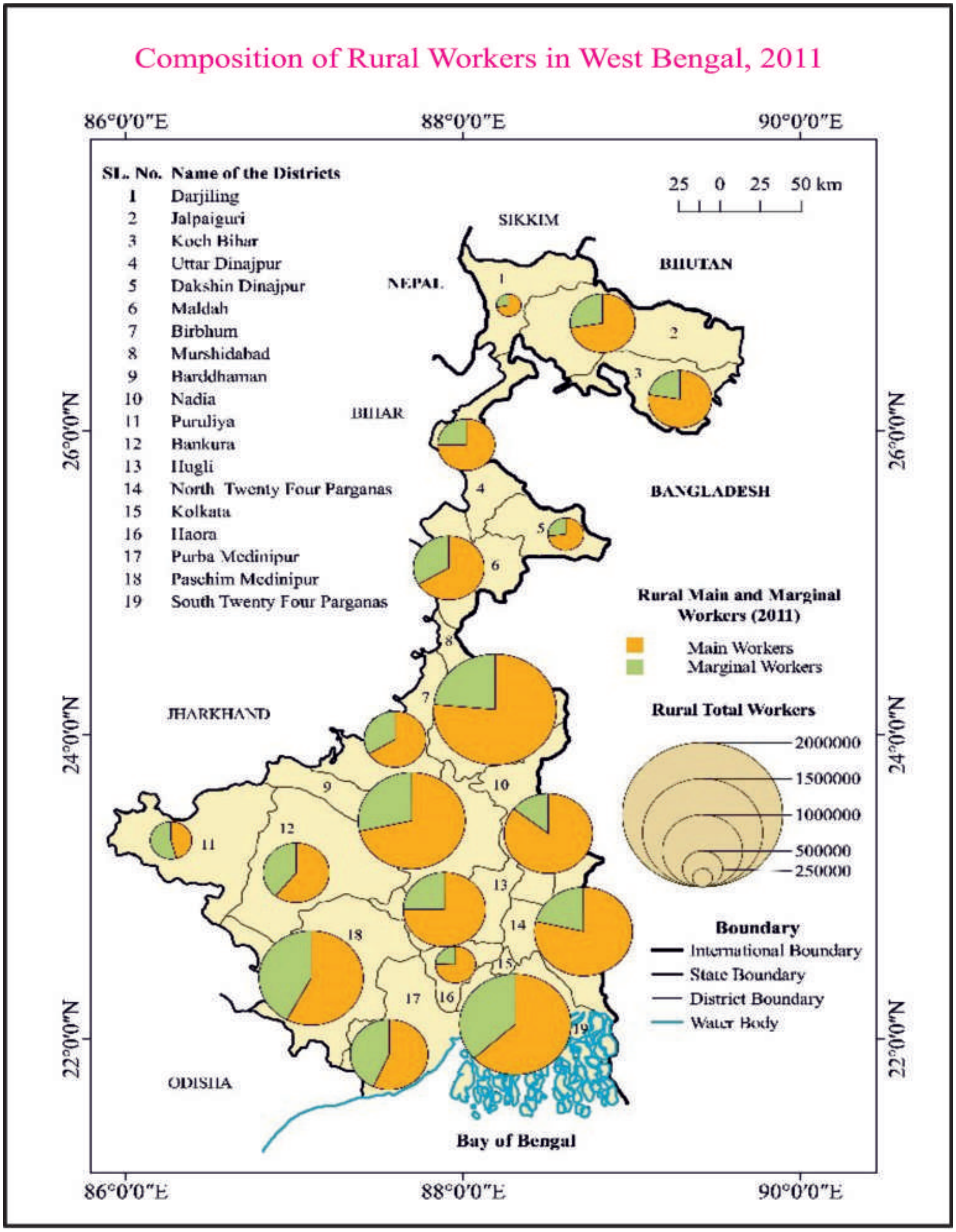

Composition of Rural Workers in West Bengal, 2001
86°0'0"E
88°0'0"E
90°0'0"E
26°0'0"N
24°0'0"N
22°0'0"N
Sl. No. Name of the Districts
1 Darjiling
2 Jalpaiguri
3 Koch Bihar
4 Uttar Dinajpur
5 Dakshin Dinajpur
6 Maldah
7 Birbhum
8 Murshidabad
9 Barddhaman
10 Nadia
11 Puruliya
12 Bankura
13 Hugli
14 North Twenty Four Parganas
15 Kolkata
16 Haora
17 Medinipur
18 South Twenty Four Parganas
25 0 25 50 km
SIKKIM
NEPAL
BHUTAN
BIHAR
BANGLADESH
JHARKHAND
ODISHA
Bay of Bengal
Rural Main and Marginal Workers (2001)
Main Workers
Marginal Workers
Rural Total Workers
2500000
2000000
1500000
1000000
500000
Boundary
International Boundary
State Boundary
District Boundary
Water Body

Fig. 1

This trend may be attributed to the rising input cost in agriculture gradually making agriculture less profitable and unsustainable for the farmers (Naik & Motkuri, 2016). Decline in the number of cultivators reflects the gradual conversion of agricultural land to non-agricultural uses, mainly for real estate and industries (Naik & Motkuri, 2016). Moreover, nature of holdings in West Bengal have changed remarkably and the number and area operated by small and marginal farmers increased in comparison to semi-medium, medium and large farmers (Ghosh, 1993). West Bengal State Development Report (2010), following the NSS 59th Survey, mentioned the farmer household with less than one hectare of operational holding was unable to meet their monthly consumption expenditure based only on the earnings from land. The landless people and sharecroppers who were assured of their tenancy rights with the successful implementation of land reforms in West Bengal have been compelled to sale their land resulting from increase in input cost and further land fragmentation due to inheritance. Consequently, many of the beneficiaries of this land reforms have ultimately converted to agricultural labourers. The composition of the marginal agricultural workers in rural West Bengal has also endured a similar trend with decline in the share of marginal cultivators and consequent rise in the share of marginal agricultural labourers (Fig. 2). Decline in the percentage share of the marginal cultivators to total workers has been observed as 7.34% in comparison to that of main cultivators' share of 3.17%.

This decline has been observed in all the districts with Bankura leading the list followed by Nadia, Jalpaiguri and Koch Bihar. It is interesting to note that, in both the agriculturally backward and agriculturally developed districts i.e. Bankura and Nadia respectively have experienced more than ten per cent decline in the share of marginal farmers. Nadia and Bankura have also experienced 23.04% and 14.33% respectively rise in marginal agricultural labourers. In all the districts except Darjiling, Haora and Puruliya, the share of marginal agricultural labourers has increased significantly indicating that marginal cultivators in West Bengal have also been compelled to sell-off their land and converted to agricultural labourers. In Darjiling and Haora, the two districts with higher rate of urbanization, presence of alternate livelihood other than agriculture seemed to have reduced the share of marginal agricultural labourers to total workers. Another significant observation is that the share of rural household industry workers has also declined in West Bengal during 2001 to 2011 (Table-1). The decline in the share of rural main household industry workers has been observed in almost all the districts except Haora and


Composition of Rural Workers in West Bengal, 2011
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8 Murshidabad
9 Barddhaman
10 Nadia
11 Puruliya
12 Bankura
13 Hugli
14 North Twenty Four Parganas
15 Kolkata
16 Haora
17 Purba Medinipur
18 Paschim Medinipur
19 South Twenty Four Parganas
25 0 25 50 km
SIKKIM
NEPAL
BHUTAN
BIHAR
BANGLADESH
JHARKHAND
ODISHA
Bay of Bengal
Rural Main and Marginal Workers (2011)
Main Workers
Marginal Workers
Rural Total Workers
2000000
1500000
1000000
500000
250000
Boundary
International Boundary
State Boundary
District Boundary
Water Body

Fig. 2

South 24 Parganas. In case of rural marginal household industry workers this decline is more evident in the districts of South Bengal except Haora and South 24 Parganas. Jalpaiguri, Koch Bihar, Uttar and Dakshin Dinajpur districts have experienced insignificant increase in this share in comparison to Haora and South 24 Parganas where the share of marginal household industry workers has increased by 5.42% and 3.54% respectively (Table-2).

Table-1: Composition of Rural Main Workers in West Bengal (2001-201)

Districts	2001				2011			
	Cultivator	Agricultural Labour	Household industry	Others	Cultivator	Agricultural Labour	Household industry	Others
Darjiling	21.025	9.571	2.406	66.999	16.324	9.694	1.885	72.098
Jalpaiguri	24.536	15.632	1.746	58.086	21.432	24.741	1.340	52.487
Koch Bihar	42.268	27.346	3.869	26.516	39.061	33.977	2.826	24.137
Uttar Dinajpur	36.305	38.601	2.929	22.165	31.184	40.533	2.619	25.664
Dakshin Dinajpur	39.800	34.169	3.994	22.037	37.770	38.477	3.746	20.007
Maldah	27.364	27.470	13.838	31.328	24.414	35.475	9.396	30.714
Murshidabad	24.248	31.544	13.959	30.250	21.845	39.415	9.751	28.990
Birbhum	29.070	33.127	5.117	32.685	24.381	44.443	3.404	27.773
Barddhaman	24.424	36.028	4.908	34.640	21.311	43.343	3.848	31.498
Nadia	26.119	29.653	8.577	35.651	25.565	39.496	5.725	29.215
North 24 Parganas	23.278	26.202	5.172	45.348	20.177	33.352	4.136	42.335
Hugli	23.016	29.171	5.132	42.680	21.647	34.332	5.036	38.985
Bankura	36.136	30.239	4.640	28.985	28.710	36.460	3.163	31.667
Puruliya	41.650	20.796	8.621	28.933	31.793	24.454	7.755	35.998
Haora	10.996	15.134	12.621	61.248	11.406	18.922	13.270	56.401
South 24 Parganas	19.493	23.615	5.266	51.625	18.148	26.252	6.072	49.528
Purba Medinipur	33.402	26.764	6.280	33.554	32.957	36.731	4.055	26.256
Paschim Medinipur					24.106	27.528	5.464	42.902
West Bengal	27.923	27.597	6.742	37.737	24.752	34.206	5.307	35.735

Source: Census of India, 2001-2011 Note: Figures are in percent

Table-2: Composition of Rural Marginal Workers in West Bengal, 2001 -2011

Districts	2001				2011			
	Cultivator	Agricultural Labour	Household industry	Others	Cultivator	Agricultural Labour	Household industry	Others
Darjiling	24.321	33.619	5.402	36.658	19.434	27.452	3.857	49.257
Jalpaiguri	22.766	36.065	2.536	38.634	10.304	42.650	2.876	44.171
Koch Bihar	34.305	46.592	4.573	14.529	22.722	51.401	5.973	19.904
Uttar Dinajpur	21.947	59.171	5.982	12.900	12.710	61.399	6.363	19.528
Dakshin Dinajpur	17.837	57.811	6.261	18.091	13.477	63.214	6.302	17.007
Maldah	9.048	44.832	22.025	24.094	7.881	49.113	19.548	23.459
Murshidabad	9.018	35.877	31.958	23.147	7.110	44.239	21.075	27.576
Birbhum	13.931	56.847	10.806	18.416	8.821	64.776	7.146	19.257
Barddhaman	10.032	58.635	7.171	24.161	7.387	65.476	5.588	21.549
Nadia	18.264	25.631	16.890	39.216	7.779	48.670	13.093	30.458
North 24 Parganas	11.227	40.055	12.433	36.284	7.242	47.453	10.571	34.734
Hugli	14.309	51.969	9.443	24.278	7.468	60.030	8.346	24.155
Bankura	25.995	49.967	7.256	16.782	13.352	64.301	5.300	17.046
Puruliya	23.097	59.990	6.872	10.041	16.510	58.932	6.664	17.895
Haora	7.264	36.849	19.041	36.846	5.480	32.921	24.303	37.296
South 24 Parganas	17.711	48.493	8.280	25.516	10.765	49.162	11.863	28.210
Purba Medinipur	24.395	47.942	10.811	16.853	14.031	63.827	8.609	13.532
Paschim Medinipur					13.608	55.868	7.756	22.767
West Bengal	18.820	48.341	10.934	21.904	11.472	55.360	9.633	23.535

Source: Census of India, 2001-2011

The decline in the share of household industry workers (considering both main and marginal) has been most evident in Murshidabad and Maldah districts. In 2001, the share of marginal household industry workers in Murshidabad was 31.96% which was reduced to 21.07% in 2011(Table-2). The decline in the share of rural household industry workers indicates that rural artisans are gradually converting towards other occupation as their household industry are becoming less profitable. In case of Murshidabad and Maldah districts, significant number of household industry workers have been migrating in different parts of this country and abroad as daily wage earners particularly as construction workers. However, in Haora and South 24 Parganas districts, increase in share of the rural household industry workers might have been a result of the proximity to the market of Kolkata urban areas. The other workers category, which includes the highly skilled professionals as well as unskilled daily labourers of rural West Bengal, presents a complex scenario. The share of main workers in this category has declined whereas the share of marginal workers in this category has increased in West Bengal. Decline in the share of this category of workers may be attributed to two factors i.e. overall decline in the formal employment (Chowdhury, 2016) and outmigration of such workers from rural to urban areas. In contrast, the share of marginal workers presumably consisting more of unskilled workers and daily labourers has increased as marginal cultivators and household industry workers have shifted to daily wage employment and self-employment in sustaining their livelihood (Chowdhury, 2016; West Bengal Human Development Report, 2004). Two districts Darjiling and Puruliya have experienced observable rise in the other workers category, both in main and marginal, for two different sets of reasons. In case of Darjiling, this increase may be attributed to the growth of tourism industry whereas in Puruliya, the other workers have increased due to absence of alternate livelihood. The study of Jatav and Sen (2013) on rural non-farm employment in India also confirmed this fact. In explaining the diversification of the rural main workers in West Bengal, it has been observed that the value of Simpson Index has decreased from 2001 to 2011 for both main and marginal workers. Reduction in the index value indicates that variety of profitable and sustainable occupation for the rural workers in West Bengal has reduced over the study period. The higher index value for the main workers than the marginal workers also indicates that this diversity has been more for the main workers than the marginal workers.

Considering the district wise variation of Simpson Index for diversification of the rural workforce, it has been observed that diversification of main workers was maximum in Maldah district and minimum in Darjiling district for both the years 2001 and 2011. This value has declined for all the districts except for Haora, Puruliya, South 24 Parganas, Jalpaiguri and marginally for Uttar Dinajpur. In the districts Haora, South 24 Parganas and Jalpaiguri approximately half or more than half of the workers have been mentioned as other category. Diversification has increased in these districts due to more accessibility towards Kolkata and Siliguri Urban agglomeration (Reardon et. Al, 2007). In Puruliya, the diversification has increased due to decline in the share of cultivators who have been forced to leave agriculture and join alternate livelihood. In Darjiling, the diversification has been found, as tourism and tea plantation provided employment to bulk of the rural folk. Most of the agriculturally developed districts however have reflected lower value of Simpson Index implying that agriculture has remained as the main employment generating activity. In the marginal workers category, except for districts Haora, the diversification index value has reduced for all the districts and reduction is greater than the reduction in the index value of the main workers. As it has already been discussed that for the rural marginal workforce in West Bengal, only significant increase has been observed in case of marginal agricultural labourers, diversification of rural marginal workers has been found drastically reducing. Haora district has reflected more diversification due to increase in the household industry and other worker category.

Conclusion

During, 2001-2011, the composition of the rural workers both main and marginal in West Bengal, has been characterized by agricultural dominance. Decline in the share of cultivators started in 1990s continued in this decade due the agricultural distress in West Bengal. Fall in public expenditure to agriculture; technological limitations and increase in the input cost are the critical factors for stagnation in agricultural growth resulting in reduction in numbers of cultivators all over the state. In spite of being less profitable, agriculture remains as the mainstay of the rural employment in West Bengal. No other activities have emerged as more profitable alternate to agricultural labourers for the rural population. The decline in the rural household industry workers also exposes the fact that government efforts and emphasis towards rural industrialization and increase in the non-farm employment did not yield intended results. The flagship programmes like SJGSY (Swarna Jayanti Grameen Swarojgar Yojna) and its continuation as NRLM (National Rural Livelihood Mission) could not provide the required impetus for the growth of rural household industries in West Bengal. Therefore, it has to be noted that diversification of workforce towards rural industries is not yet been proved as a viable policy option. The reduction in the diversification of rural workforce in West Bengal is attributed to poor asset base, lack of credit facilities and skill formation along with remoteness of the districts (Saha & Bahal, 2010; Khatun & Roy, 2012). Therefore, in order to ensure sustainable employment to the rural people, the location specific agro-climatic constraints need to be overcome along with accessibility and connectivity with nearest urban centres and availability of financial infrastructure have to be emphasized.

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LIVELIHOOD ADJUSTMENT AMONG BHOTIA TRIBES WITHIN THE SOCIAL FABRIC OF THE MOUNTAIN TRIBAL COMMUNITY: A CASE STUDY OF BHOTIAS OF GARHWAL HIMALAYAS

Roosen Kumar and Dr. Bindhy Wasini Pandey

Abstract

Himalayas is known for its spectacular beauty as well as for its diverse cultures. The Niti valley in Chamoli district of Uttarakhand and Bagori village (in Harshil valley, Uttarkashi) is inhabited by Bhotia tribes. The Bhotias of Niti valley are specifically the Marchas, a community of Mongoloid descent, and the Tolcchas, both collectively referred to as Rongpa. The Bagori village is habited by Bhotias of Nelong and Jadung valleys. Their settlement reflects Indo-Tibetan culture. The Bhotias traditionally practiced trade, agriculture and transhumance across the border. However, after the Indo-China war in 1962, the Indo-Tibetan socio-cultural and economic exchange came to an end. This paper attempts to show several livelihoods changes, social and cultural changes that the Bhotia community has experienced over time. The paper further identifies the challenges associated with those socio- cultural changes that have taken place. The modernization and outside development have largely influenced the traditional systems of the community. The shift away from their traditional occupation can be seen among the Bhotias. The culture of transhumance have reduced drastically and livestock based dependency is almost negligible. Thus, socio-cultural changes can be seen in the region. Transforming livelihoods also fabricates substituting culture as the two are intimately connected. The environmental, social and economic settings in the region have altered the community's traditional lifestyle and occupation due to which alternative livelihood opportunities are being explored by Bhotias. Further, increased globalization and modernization has changed the attitude towards exploring other possibilities, especially younger generations of Bhotias.

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Introduction

The impregnable Himalayas in the north is not only studded with glacial peaks, lush greenery, or ghastly rapids but also socio-anthropological elements such as tribes, communities, and their cultural heritage. Along with geopolitical importance, borders of mountain areas consist of vulnerable ecosystems and vulnerable communities, residing far from the decision-making process (Sharma et al., 2019). Within the social fabric of the mountain tribal community, the Bhotia tribe remains one of the most widely discussed tribes. Bhotias are the ethnolinguistic tribe inhabiting the higher reaches of central Himalaya bordering Tibet and Nepal. They inhabit mostly in the states of Uttarakhand, Jammu & Kashmir, Himachal Pradesh, Sikkim, Assam, Arunachal Pradesh, Uttar Pradesh, West Bengal, and Tripura (Sharma, 2020). The literal meaning of 'Bhot' is north. Perhaps the people of Garhwal and Kumaon use the word 'Bhotia' for the people's lives or coming from the north (Chatterjee, 1976). In the state of Uttarakhand, Bhotias populated the districts of Chamoli, Pithoragarh, Almora, Uttarkashi, and Nainital which mainly covered the north-eastern part of the state, known as Bhot Pradesh (Maiti, 2009). There are eight types of groups within the Bhotia tribe- Johari, Juthora, Darmi, Chudans, Byansi, Marccha, Tolcha, Jadh which are diffused over eight river valleys of Uttarakhand- Johar, Darma, Byans, Chaudans, Mana, Niti, Nilang, Jadung (Bhatt et al., 2009). According to the Census of India, 2011- total 39,106 Bhotia population living in India with Scheduled tribe status of which 37,873 are Hindu and 1,100 are Buddhist. Generally, livelihood denotes the ways, means, activities, assets, and entitlements with the help of which people sustain themselves.

The livelihood opportunities or options for Bhotias are as dispersed as their population. The highly developed trade organization, subsistence agriculture, handicrafts, and pastoralism are some options of income for them. Tiny patches of land due to high altitude, the scope for intensive farming is null (Bhatt et al., 2009; Nautiyal et al., 2003). Livelihood pattern of Bhotia community shows a 'Geo-Economic Syndrome' in which six syndromes are identified- transhumance, mait or summer settlement, gunshas or winter settlement, mountain pass near Tibetan border area, mandi or market in Tibetan area, market near the foothills of Indian territory (Chatterjee, 1976). Due to inadequate educational facilities, very few Bhotia people migrate to summer villages. Trade- traditional occupation of Bhotiyas suffered a setback because of the Chinese occupation of Tibet and the Chinese invasion in India in 1962 which subsequently resulted in the sealing of the northern border of India.

This vigorously affected Indo- Tibetan trade, mainly the traditional livelihood of Bhotias (Maiti, 2009). Forest grooves contain not only cultural or religious value but also livelihood importance. In contemporary times, Bhotias are in a vicious cycle of losing control of natural resources along with being unable to tackle new dimensions of work and resources for sustenance. The long-term out-migration of men from Uttarakhand's mid-hills creates an unbalanced pressure on women (Everard et al., 2020). Degradation of local environment along with the erosion of natural resource base for the transhumance community caused by human-induced activities have emerged as major problems (Prasad et al., 2016). Inconsistent rainfall, the unforeseeable onset of monsoon, storms, the retreat of glaciers, drought, landslides are some observed impacts of climate change in the mountainous regions causing crop failure, concomitant food and livelihood insecurity, water scarcity and addition to income insecurity (Saxena et al., 2005; Dimri et al., 2021). In higher reaches of Uttarakhand, Climate change is causing changes in livelihood capital, agro-livestock conditions along with the emergence of invasive species (Semwal et al., 2004). The grave impact can be seen in the agricultural sector which entails the highest proportion of the workforce of Uttarakhand (Rasul et al., 2020). Although a high level of out-migration is the primary cause, there is a significant role of climate change effects on the livelihoods based on forestry, agriculture, livestock husbandry, non-timber forest products etc. (Rautela and Karki, 2015).

Study Region

The present study is based on the Niti valley (located in the Chamoli district) and Bagori village (in Uttarkashi) of Uttarakhand. Both, the Niti valley and the Bagori village is a settlement of the Bhotia community. According to census 2011, the total population of Surveyed villages in Niti valley is around 1400. The Bagori village has a population of 567 people and has 155 households. The influence of Tibetan culture can be seen as the people practice both the Hindu and the Buddhist religion. The settlement of Bhotias in both the places reflects knowledge of unique construction techniques. Such house forms can be associated with a community's response to climatic and social factors like pastoralism and agriculture. Even in the 21st century, these remote villages are less explored. However, the village is experiencing growth in tourism and pilgrim over a few years. The villages are generally occupied by elderly population as youth and young population has out-migrated due to lack of proper facilities at their native places.

Objectives

This paper attempts to show several livelihoods changes, social and cultural changes that the Bhotia community has experienced over time. This study further identifies the challenges associated with those sociocultural changes that have taken place.

Data Sources and Methodology

The study is based on a primary survey as well as on the basis of review of several secondary sources. Intensive field survey was carried out to cover the dimensions of the study. The respondents were selected using stratified sampling for survey purposes. Through field survey, using participatory rural appraisal technique, perceptions of the Bhotia community regarding their traditional livelihood were identified and documented. The perception of the elder people of the community who have been staying in the area for a long time have been included through interviews and focus group discussions. The perspective of Bhotia individuals were documented for those who still practice transhumance and those who were once engaged in the practice. In order to understand the socio-cultural changes and changes in transhumance practices over the years, Snowball sampling was used by approaching target population. A transact walk was carried out in the village to look over the social and cultural organization of the community. A qualitative approach has been followed. The secondary sources of data included published materials such as research papers and magazines.

Results and Discussion

Socio-economic Structure of Bhotias of Niti Valley

The Bhotias of Niti Valley and the Jadh Bhotias have evolved distinct socio-economic systems due to their unique geographical settings, livelihoods, and historical interactions. Both communities are high-altitude pastoralists and traders, but their socio-economic structures reflect their different circumstances, including their history, migration patterns, and government policies. The Bhotias of Niti Valley are concentrated in the villages of Niti and surrounding areas in the Chamoli district, close to the Niti Pass on the Indo-Tibetan border. The Niti Bhotias were historically involved in cross-border trade with Tibet, trading items like salt, wool, and grains. After the closure of the border in 1962, they turned to pastoralism, though many practice agriculture as well at present. They cultivate high-altitude crops such as potatoes, barley, and rajma (kidney beans) during the summer months.

The severe winters force them to migrate to lower altitudes, which limits agricultural productivity. They rear sheep, goats, and yaks, using high-altitude pastures during the summer (Fig. 1). The Bhotias of Niti Valley have a mixed Tibetan Buddhist and Hindu identity. Their traditional dress, language, and customs show strong Tibetan influences. The Bhotias are organized into clan-based systems, and village councils play a role in decision-making, particularly regarding the use of communal resources like pastures. The Bhotias of Niti have somewhat better access to education and government services than the Jadh Bhotias due to being closer to the district headquarters in Chamoli. Many members of the community have sought employment in government jobs or small businesses. With the rise of tourism in the Niti, the Bhotias have diversified their economy by offering handicrafts like woven woollen items, and some households operate guesthouses for trekkers and pilgrims. The Bhotias have benefitted from the Border Area Development Program and other government schemes aimed at improving infrastructure, education, and healthcare in remote border areas. The closure of the Indo-Tibetan trade route in 1962 deeply impacted their economy, forcing them to shift from trade to subsistence agriculture and pastoralism. Many young Bhotias out-migrate in search of better education and employment, leading to a shrinking local population and an aging demographic in the villages.

Socio-economic Structure of Jadh Bhotias of Bagori

The village Bagori is inhabited by Bhotias that mainly resides by the Trans Himalayan belt. The people residing in the Bagori village recognize themselves as Jadh Bhotias. They are also distributed around the high-altitude belts of the central Himalayas, mainly near the Indo-Tibetan and the Indo-Nepal borders. The Bhotias traditionally have been engaged in several occupations, mainly trade and pastoralism. Their main livelihood was dependent on livestock. This tribe is a semi-nomadic tribe that inhabited higher valleys of the river system of Bhagirathi in the district of Uttarkashi. They formerly occupied Nelang and Jadong valley along the Jahanvi or Jadh Ganga river (tributary of Bhagirathi). Therefore, they are recognized as Jadh Bhotias (Photo-1). The harsh climatic conditions in the higher regions of the Himalayas provide limited occupation. The Jadh Bhotias depended upon pastoralism and followed seasonal transhumance. During summer, they used to settle in Nelong and Jadong valley to trade goods with Tibetan merchants. During the extreme winter season, the community used to migrate to other places to graze their livestock. After the Indo-China war in 1962, the Indo-Tibetan socio-cultural and economic exchange ended. This was the time when this tribe was relocated

Abandoned Houses of Bhotia in Niti Valley

Photo-1

in Bagori village from their original place (Nelong and Jadong valley). There are many reasons for their settlement in Bagori village. Before reaching the Nelong and Jadung valley, Bagori was used as a camping site as it was a part of trade route between India and Tibet. Therefore, familiarization as well as association along with prior knowledge of the place was the key reason for their resettlement in the Bagori village (Fig. 2).

Traditional Livelihood Linkages and Developments

The traditional livelihood linkages of Bhotias of both the places can be associated with trade, agriculture and transhumance (Fig. 1). Before 1962, the community was engaged in trade across the border. The rare commodities, meat, milk and woollen products were brought from Tibetan markets and were sold in Indian markets. From the Indian market, the community used to carry rice, wheat, and other granaries to Tibetan markets. Thus, the trade system was well established in the region. The major source of livelihood production in the region are agriculture, pastoralism, trade in woollen garments and high value medicinal herbs. This production system has been affected by environmental uncertainties to a large extent. However, after the 1962 war, the cross-border trade and the traditional livelihood linkages of the community came to an end. The community in the Niti valley and those in Harshil valley (after resettlement in Bagori) faced many socio- economic challenges. It's a fact that the transhumance has been the primary base of livelihood for the Bhotias in the highlands. There are several studies that found that the pastoral culture has reduced drastically. One of the reasons for such drastic change can be associated with changing socio-economic and environmental conditions of the highlands. The challenges posed by such conditions have reduced the livestock population. The types and number of livestock has changed in the region. Even very few families who still practice transhumance face numerous environmental and socio-economic challenges to sustain transhumance culture.

The livestock are very well adapted to the climatic conditions of a particular area. The change in climatic factors induce changes in environmental settings that directly affects the livestock population. There has been a huge reduction in the number of Bugyals that were used for grazing purposes. The reduction of the Bugyals directly affected the livestock composition. It has been found that the ecological variations have negative impacts on rangelands. This directly affects the distribution of livestock population. It is a matter of concern as the future temperatures are expected to increase. The increase in temperature in the highlands and associated dynamics have been reported across the world. The impact of this can be seen in

Niti and Bagori as well. Apart from decline and distribution of livestock, there has been shortages of fuels and fodder and pasture land degradation at higher altitudes (Fig. 3). The economy in the region or the dependence of the people in this region was mainly on the livestock. The livestock included local breeds of milking and draught animals. In order to fulfil the household requirement of milks and meat as well as to support agricultural or farm production, the dependence on livestock was huge. However, at present, there has been a huge decline on the livestock-based economy. The people who were once fully dependent on the livestock, the assets such as livestock are extremely limited among them at present. The rural people or households prefer to keep lesser number of livestock in comparison to the past. As raising livestock proves expensive for them and doesn't give desired income therefore, alternative occupations are more beneficial. The social and economic changes happening around has forced people to leave this occupation. At present, very few families are dependent on livestock. Most of the families have changed their livelihood options as the traditional pattern of livelihood doesn't support them to sustain. The developmental processes and modernization in high altitude regions have largely affected the management of livestock systems and other resources. Such processes have a profound influence on indigenous pastoral system and people of the area. The traditional livelihood based on pastoral production system has experienced a shift away towards new systems of production, management, adjustments and adaptations. The Sino-Indian war resulted in termination of border trade causing economic disaster for the Bhotias. Since the closure of well-established trade across the border, the community have adjusted and adapted to other livelihood sources such as, subsistence as well as commercial farming, limited pastoralism and trade in high value medicinal as well as woollen products. The socio-economic and ecological potential is very limited in high altitude regions due to extreme harsh conditions. These high-altitude regions have been subjected to exploitation and inappropriate management of alpine resources, therefore, it remained to be a matter of discussion for environmentalists. Such environmental concerns examined changes in alpine resources, trends of change, production and consumption patterns and various other parameters related to high-altitude ecological systems.

The non-agrarian economic influences and opportunities have resulted in the lack of workforce in the region. As a result, there is limited workforce to fulfill herding demands in the region. The changes aren't visible only in one community, but across all the pastoral communities in the Himalayas. The use of alpine meadows for grazing has declined drastically. The new market trends and developmental initiatives have discouraged grazing in high altitude regions. The remote and inaccessible regions have been linked with roads and thus, increased transportation and communication have integrated the multicultural peripheral societies with new market trends. With these induced changes, the production priorities of the local communities have changed. Socio-economic modernization, external innovations and population pressure within the communities have also influenced the production systems. However, the major change has occurred due to employment opportunities in non-agricultural sectors. The marginal, fragile and inaccessible nature of the Himalayas along with these scenarios have further increased the livelihood vulnerability among Bhotias. As a result, the diversification of occupation can be seen.

Changes and Challenges

The inadequate resource base in the high-altitude settlements has forced the local community to develop approaches to use and manage available resources in best possible ways. Outside influence can be seen in the region that has come from increased trade and commerce as well as from increased influx of tourists. The outer exposure and employment opportunities have enlarged due to introduction of services. The increased interaction and interference between local people and the outside world have also influenced the traditional lifestyle of the people. The younger generation do not want to continue with their traditional livelihood production system. They are more inclined towards new market trends. As there is absence or shortage of young workers from the community, the pastoral families hire workers to graze their animals in the alpine pastures. Another concern of hiring the workers is that they do not follow the established traditional customs and rules of pasture management which ultimately affects traditional practices of the community. The changes are also visible in the consumption system. Earlier, high-altitude traditional crops were cultivated and consumed by Bhotias. High value crops grown traditionally were sold in urban areas for better prices. However, now they cultivate these crops but they are not subsistence in nature. The consumption of fine grains such as, wheat and rice has increased over the time. Thus, the social and cultural values ascribed to these fine grains is significantly more expensive than their traditional coarse grains.

This has also resulted in an increased competition for agricultural land. The diversity of traditional crops has been seriously affected. Number of traditional crops are less known to young generations today and could vanish. The locals had realized the risk associated with their traditional livelihood in changing environmental, social and economic conditions. They see alternative occupations as less risky and more profitable. The change in livelihood pattern isn't the only change in the community. Most of the pasture lands have been declared as protected areas and therefore, pastoralists have no access to their traditional resource base. This has seriously affected their survival. Also, the land use and land cover has changed significantly that further makes survival difficult while depending on traditional sources of income. To achieve equality in distribution of resources, regulation of livestock grazing and resources through local communities is practiced. Local people practice resource management. This not only protects traditional crops but also diminishes the ill effects of grazing in the long run. Along with this, it also protects the wild grasses in the growing season from the livestock, depicting a human relationship in the natural resource management cycle through agriculture. Regulation of resources and livestock grazing by a community is the best example of increased sustainability which is the direct result of self-control, discipline and community prosperity. Unfortunately, infiltration of elements of other societies, along with people's cravings for more income, turn out to be a break of slope in the strictly adhered restrictions of the communities. Due to declining traditional values, practices have been driven towards the instruments of profit-making, shifting towards a 'modern' and 'better' urbanism. Not only profit-making but also accumulation of material wealth has become the major focus of the society, which stands in stark contrast with the earlier condition. Earlier, there was no selfish desire or stockpiling of resources people used to live in integration by sharing their natural resources (Table-1). This is a major concern for their indigenous practices as it is imposed upon them, camouflaging with the so-called development blanket. The comparison between Bhotias of both the places can be seen in the table below.

Table-1: Comparison between Bhotias of Niti Valley and Bagori Village

Challenge	Jadh Bhotias	Bhotias of Niti Valley
Geographic Isolation	Extreme isolation in restricted border area	Relatively better access, but still remote
Climate	Severe winters, transhumance	Similar conditions, but better tourism
Economic Diversification	Primarily pastoralism, limited diversification	Tourism, handicrafts, and agriculture

Contd...

Cultural Erosion	Cultural loss due to migration	Cultural erosion, but slightly better
Education & Healthcare	Poor, services available	Slightly better, but still inadequate
Tourism Potential	Restricted due to border proximity	Seasonal and limited due to infrastructure
Dependency on Agriculture	Minimal, more reliance on pastoralism	Short growing season, limited output but more reliance on agriculture

Source: Authors

There are several other dynamics associated with these ongoing changes. One such example is the change in housing techniques. The construction technique of houses with the help of locally available materials and knowledge have been passed to new generations of the Bhotia community. However, this traditional skill and knowledge has declined today with the decline in the number of masons having particular housing skills. At present, the people in the village have started using modern materials and technology for construction of houses as maintenance of traditional houses is tough due to lack of traditional knowledge. After resettlement in Bagori village, the Indo-Tibetan trade came to an end. The case is similar in Niti valley where traditional houses are being replaced by modern brick houses. The younger generation of this community have migrated to other places in search of livelihood as the region poses a huge lack of opportunities. Such migration has left several houses abandoned. The scenario is similar for Bhotia community of Chamoli district. Apart from this, as the tourism has increased, the old houses of Bhotias are being converted into homestays for generating income. The abandoned houses of the Bhotia symbolize the profound socio-economic alterations and livelihood adjustments that the community has faced. These structures are a testament to the shifts that forced the Bhotias to abandon their traditional homes and ways of life, largely due to the disruption of their trans-Himalayan trade routes, environmental changes, and the need to seek alternative livelihoods elsewhere. The empty homes reflect the migration of families to other regions for better economic opportunities, illustrating the broader narrative of adaptation and survival in the face of changing socio-economic conditions, as discussed in the context of the Bhotias of Garhwal Himalayas. Bagori village where Bhotias relocated themselves and Niti valley is transforming rapidly. Such an increased alteration poses a threat to the socio-cultural identity of the community.

The outside market economy has largely influenced the social structure and value of production systems of Bhotias. These influences are threatening Bhotias traditional system of livestock - land use management as well as their indigenous knowledge. Therefore, it becomes necessary to create and promote socio-cultural awareness among the new generation to preserve long-established traditional knowledge. These challenges can be attributed to socio-economic and environmental circumstances. The socio-economic alterations experienced by the Bhotia tribes of the Garhwal Himalayas have led to significant livelihood adjustments, as depicted in the diagrams. Traditionally reliant on trans-Himalayan trade, the Bhotias faced drastic changes when political and environmental factors disrupted their established economic practices. The Bhotias of Niti Valley have benefitted more from the rise of tourism and government programs, diversifying into handicrafts and hospitality, whereas the Jadh Bhotias remain more reliant on agriculture and pastoralism. Niti Valley Bhotias have closer access to markets in Joshimath and Chamoli, enabling better trade and access to services, while the Jadh Bhotias are more isolated. While both communities practice transhumance, the Jadh Bhotias migrate over longer distances and for more extended periods compared to the Bhotias, affecting their economic stability. While both communities face challenges related to their remote locations, harsh climates, and the closure of traditional trade routes, the Bhotias of Niti Valley have adapted by diversifying into tourism and local industries, whereas the Jadh Bhotias remain more reliant on pastoralism with limited economic diversification. Both groups benefit from government programs, but their progress in modernizing and improving their socio-economic conditions differs based on geographical advantages and access to resources.

Conclusion

The pastoralist's livelihood in many parts of developing countries is mainly associated with their livestock directly, and therefore to the natural environment in which they reside. In the extreme winters, the community still practices seasonal transhumance. However, very few families practice transhumance at present. The dependence on livestock for livelihood has declined largely. Today, most of the Bhotias have shifted their occupation from transhumance to other sectors, mainly agriculture. The survival based on livestock is hard as they do not generate enough income. Therefore, they see economic prospects in some other livelihood options. This is mainly due to climatic and other external factors such as development around the adjoining regions. This change in attitude is also a result of acculturation. Today, both the places is known for its Rajma cultivation. The traditional occupation of Bhotias such as shearing of sheep, spinning and weaving can be seen practiced by older generations. The new generation generally migrate for education or in search of jobs. The younger generation are hardly indulged in their traditional sources of livelihood. The effect of increased modernization can be seen on Bhotias social and cultural practices. The hardship nature of traditional occupation is becoming less attractive for locals. The development in the highlands is limited and therefore, inhabitants of the mountains have to be provided with better livelihood options considering the conservation of mountain biodiversity. Apart from conservation of biodiversity, there is a need to conserve traditional.

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URBANIZATION VS AGRICULTURE: MONITORING LANDUSE CHANGE IN FATEHABAD CITY, HARYANA (2001-2021) USING GEO-SPATIAL TECHNIQUES

Rahul and Poonam Chandel

Abstract

The 20th century marked a significant period of development, presenting both opportunities and challenges. While development is essential for progress, the focus on sustainable development has become crucial for ensuring a safe and prosperous future. India, a developing nation, is in the early stages of its development journey. Rapid urbanization, population growth, and increased resource accessibility have driven modernization, particularly in cities. The number of towns and urban agglomerations in India has grown substantially, with Census towns increasing from 1,362 in 2001 to 3,894 in 2011. Haryana, once recognized for its agricultural prosperity when it became a state in 1966, has witnessed significant urban growth. In 1971, urbanization in Haryana was limited to a few districts, with an urbanization rate of 17.66%. By 2011, this had risen to 31.16%, with Fatehabad experiencing an increase in urbanization from 11.17% to 19.06% (Census of India, 1971-2011). Urban expansion in smaller cities, including Fatehabad, has increasingly encroached upon agricultural land, leading to pressure on agricultural zones and intensification of land use. Nationwide, less than 1% of agricultural land was lost to urban development from 2001 to 2010, amounting to 0.7 million hectares. This study focuses on Fatehabad City, where approximately 850 hectares of agricultural land have been lost to urban built-up areas between 2001 and 2021. During this period, urban built-up areas have increased by 89 percent. The study employs remote sensing and GIS techniques to monitor these changes and analyse the impacts of urban expansion on agricultural land. Timely monitoring and effective control of such growth can help balance urban development with the preservation of agricultural areas, ensuring sustainable land use in both urban and peripheral regions.

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Introduction

The 20th century marked an era of rapid development, bringing both positive advancements and challenges. While development is essential for survival and progress, there is a growing need to focus on sustainable development for a safer and brighter future. As a developing nation, India is in a continuous phase of growth, with increasing opportunities, rising populations, and better access to resources leading to cultural modernization, especially in urban centres. India's urban areas have significantly expanded, with Census towns increasing from 1,362 in 2001 to 3,894 in 2011 (Pradhan, 2017). When Haryana became a state in 1966, it was known for its agricultural prosperity. By 1971, urbanization was limited to certain pockets, such as Ambala, Yamuna Nagar, Karnal, and Panipat, which were more urbanized than the state average of 17.66%. By 2011, Haryana's urban landscape had evolved significantly, including increases in urbanization in districts like Fatehabad (Census of India, 1971–2011). Rapid urban expansion often lacks regular supervision, resulting in uncontrolled growth that impacts productive land. In many small cities, agricultural land is encroached upon for urban expansion, leading to agricultural pressures like intensification. Across India, approximately 0.7 million hectares of agricultural land were converted to urban use from 2001 to 2010 (Pandey & Seto, 2015). About 50% of India's land resources are already degraded, and unchecked urban sprawl contributes to environmental degradation (Varughese et al., 2019). These concerns have made urban expansion a significant topic at global summits, including the 2005 Rio Summit and the UN's Agenda 2030 for Sustainable Development (Sharma & Kumar, 2023). Studying urban expansion is essential for effective urban planning and land resource management. Urban expansion has led to peri-urbanization, affecting rural areas and their socio-economic activities (Coulibaly & Li, 2020). Small to medium-sized cities also face rapid agricultural land loss, indicating that examining urban sprawl should extend beyond major cities (Habibi & Asadi, 2011; Pandey & Seto, 2015). Globally, cities expand through lateral sprawl, high-rise construction, and densification, affecting agricultural and natural areas, including forests and riverbanks (Angel et al., 2021; Marconcini et al., 2021).

In urbanized areas, urban infrastructure increasingly replaces natural landscapes (Bren d'Amour et al., 2016; Singh et al., 2024). Researchers have identified various factors influencing urban built-up expansion: such as economic growth, demographic changes, housing needs, and transportation (Brueckner, 2000; Fulman et al., 2024; Jenerowicz & Bielecka, 2022; Dadashpoor &

Shahhossein, 2024). As regular monitoring and study of urban areas is important for resource management. Remote sensing plays an important role as it gives real-time data of a large spatial extent (Fu & Weng, 2016). This data is easy to process and analyze for urban studies with various models and tools provided by GIS. In Haryana, urban zones are defined based on proximity, cluster arrangement, and the influence of large urban centers. Fatehabad, for example, lies within the Sirsa-Fatehabad zone, with Sirsa as its central urban hub (Bansal & Tyagi, 2019). The purpose of this research is to examine the urban built-up expansion of Fatehabad city of Haryana from 2001 to 2021. To analyze and calculate how much agricultural land in the surrounding area has been consumed by the city over the period.

Study Region

Fatehabad a historical town and present district of Haryana has always had its name from the past. The town Fatehabad was founded by Firoz Shah Tughlaq on his son's name Fateh Khan. It is located between 28°48'15" to 29°17'10" north and 76°28'40" to 77°12'45" east longitude. It is a tri-junction of three states, Punjab from the north, Rajasthan from the south and in the west, there is the Sirsa district of Haryana. The district is ethnically very versatile as it is coherent with the cultures of the three states. Its historical background also shows that it has been under the rule of various empires like the Mughals, Nanda, Mauryas. The District Fatehabad is also famous for its archaeological sites of the Harrapan civilisation. The population of the district is 8,06,158 according to the 2011 census. The main occupation in the region is agriculture as it is part of an alluvial track of river Ghaggar and Sarasvati River which is now dried up. Fatehabad is 19th out of 21 in urban population with 2.03% of the state's urban population (Bansal & Tyagi, 2019). The population of Fatehabad municipality was 59,917 in 2001 census and 70,777 in 2011 census (Census of India, 2001 & 2011).

Objective

To analyse the built-up expansion from the city to different directions with agricultural land loss.

Data and Methodology

This study is done to analyze the land use land cover in Fatehabad municipality and its control area and agricultural land consumption due to urban expansion. The Landsat-5 and Landsat-8 images are downloaded from USGS Earth Explorer. For the pre-processing and processing of data, Q-GIS 3.8 software is used.

For the classification of data, the Random Forest technique is used to divide the area into four classes which are: Built-up, Agricultural land, Water bodies and Open land. The layouts of the maps were prepared using ArcGIS software. For the analysis Landsat Imageries of 2001, 2011 and 2021 were utilized to find the area under different LULC classes and how much agricultural land is being converted to built-up due to urban expansion.

Result and Discussion

Land Transformation

The expansion of cities and towns, or urbanisation, is a worldwide process fuelled by social change, population growth, and economic development. The loss of agricultural land is one of the major detrimental effects of urbanisation, despite the fact that it also has many positive effects including better infrastructure, employment possibilities, and service accessibility. An important resource that produces food, fibre, and other necessities is agricultural land. But when cities grow, they intrude on rural areas, turning them into commercial, industrial, and residential districts. Food security, environmental sustainability, and rural livelihoods are all significantly impacted by this transfer of agricultural land to urban built-up regions. Evaluating and determining the amount of nearby agricultural land that Fatehabad has absorbed between 2001 and 2021 is the aim of this study. Haryana's Fatehabad district is primarily an agricultural area. The city is growing and the amount of agricultural land is decreasing as the urban population has doubled from 1951 to 2011 (8.84% to 19.06%) and is still growing. The control area of Fatehabad City is used to monitor the built-up area's expansion outside the municipal boundaries. To extract the built-up and agricultural land within the control area, LULC maps from 2001, 2011, and 2021 have been created (Fig. 1 and Table-1)

Table-1: LULC Classes and Area (2001, 2011 and 2021)

LULC Classes	2001 Area (ha)	2011 Area (ha)	2021 Area (ha)	2001-2021 Change (%)
Waterbodies	17.28	17.91	27.81	60.94
Built-up	948.87	1184.49	1801.17	89.82
Open/fallow land	68.58	68.49	175.32	115.64
Agricultural Land	7242.03	7005.87	6272.46	-13.39

Source: Landsat Images of 2001, 2011 and 2021

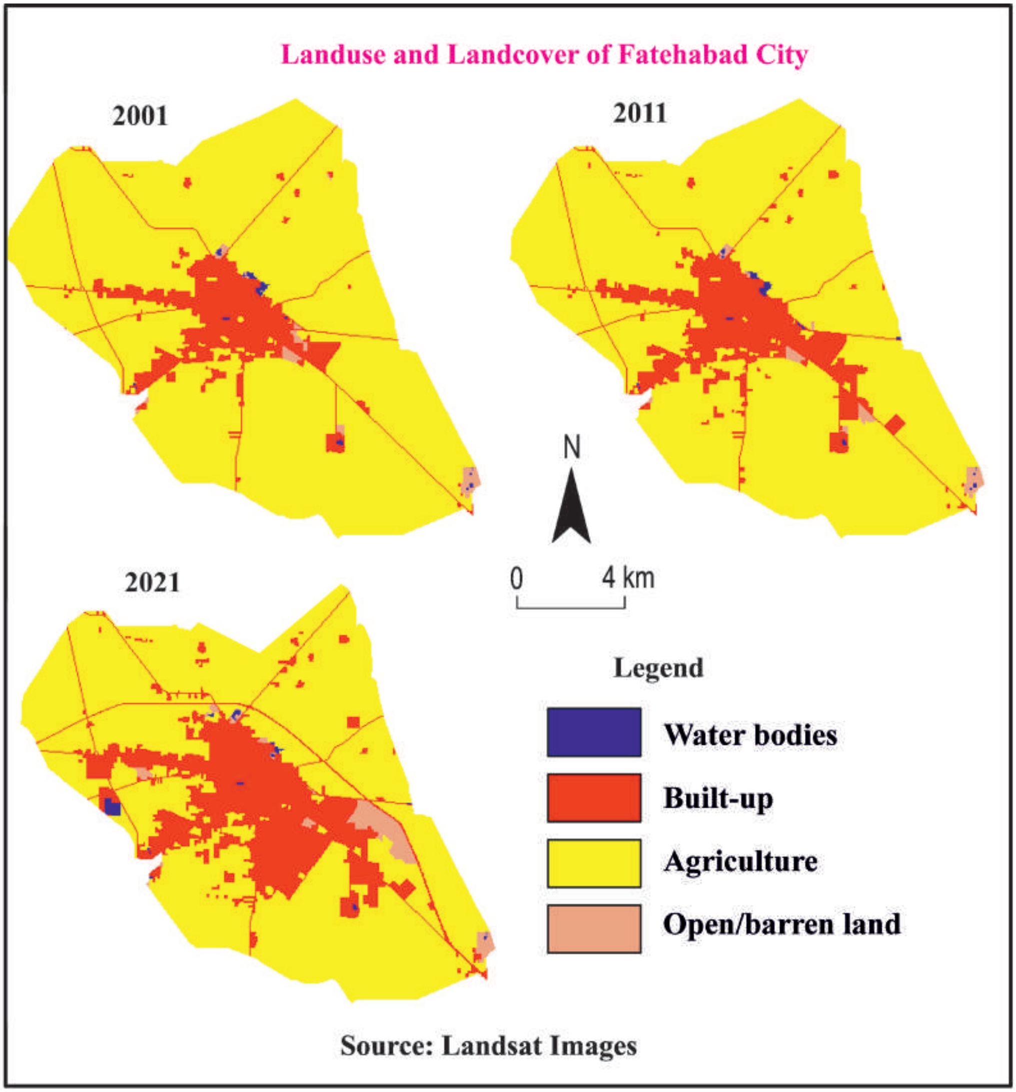
Landuse and Landcover of Fatehabad City
2001
2011
2021
N
0
4 km
Legend
Water bodies
Built-up
Agriculture
Open/barren land
Source: Landsat Images

Fig. 1

The analysis of LULC (Table-1) reveals that the area under the water bodies, built-up and open land continuously increased on the amount of loss of fertile agricultural land. The LULC classification shows a continuous increase in built-up and open/barren land area from 2001 to 2011 and 2021. The total area under built-up was 948.87 hectares in 2001 which covers the city municipality. But after 2001 the increase in built-up was continuous and the city extended outward its municipal boundary. In 2021 the area under built-up rose to 1801.17 which is almost double the area of 2001. Open/Barren land had an area of 68.58 hectares in 2001 which decreased to 68.49 hectares in 2011. But after 2011, the Hisar-Sirsa (Bypass) Highway was constructed. This class has shown a sharp increase along this road from 68.49 to 175.32 hectares. The significant reason for the increase in area under the open space was the acquisition of agricultural land by the builders to convert the land into residential zones. It was also noted that the fertile agricultural land was initially converted into open space that into built-up area. As a consequence of the increase in built-up and open space, the agricultural land area was shrunk to 6272.46 hectares in 2021 from 7242.03 in 2001. A major loss in agricultural land was also observed after 2011. The area under the water bodies increased from 2001 to 2021 as a result of the construction of water works and the expansion of ponds and Sewage drainage. Urban expansion is the major reason for the loss of fertile agricultural land. The expansion is mainly along the major roads and there is also more open space in this area as a result of land being acquired for new residential colonies, institutes, factories and public utilities. The edge expansion plays a significant role in the city sprawl. The increase in built-up and open spaces is directly linked to decreased agricultural land. This also indicates that the city will expand further in the foreseeable future (Fig. 2 and Table-2).

Table-2: Loss of agricultural land to other classes between 2001 and 2021

Change from Agricultural to other class	Change (Area Ha)
Agricultural to Water	17.19
Agricultural to Built-up	824.49
Agricultural to open/ Barren land	134.55

Source: Calculated from the Landsat Images, 2001 and 2021.

The loss of agricultural land has been analysed by applying the matrix union. The result is shown with the help of Table-2 and Fig. 2 depicts the spatial distribution of agricultural loss between 2001 and 2021. The major loss of agricultural land was in the form of built-up followed by open space and water bodies.

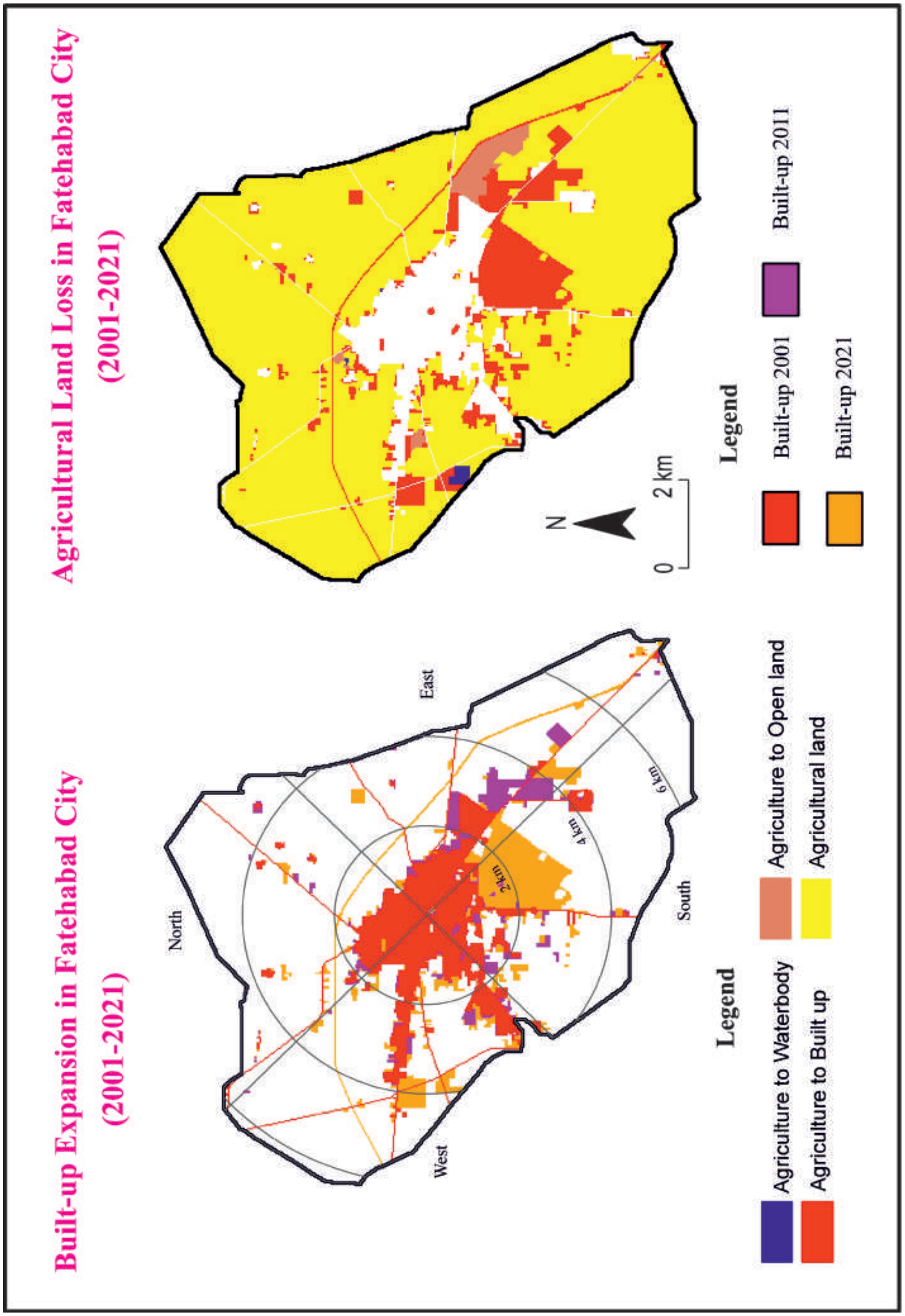
Built-up Expansion in Fatehabad City
(2001-2021)
North
East
South
West
2 km
4 km
6 km
Legend
Agriculture to Waterbody
Agriculture to Built up
Agriculture to Open land
Agricultural land
Agricultural Land Loss in Fatehabad City
(2001-2021)
N
0
2 km
Legend
Built-up 2001
Built-up 2011
Built-up 2021

Fig. 2

There were 972.9 hectares of agricultural land lost during the two decades from 2001 to 2021. Out of which about 824 hectares of agricultural land were converted into a built-up area and 134 hectares were transformed into open land. Only 17 hectares were converted into water bodies. This rapid expansion of built-up over the fertile agricultural land is a serious concern.

Directional Distribution of Built-up Expansion

The directional distribution of built-up expansion is shown in Table-3. The study area was divided into four cardinal directions- North, East, South and West (Fig. 2). The analysis revealed that the south direction experienced the highest built-up expansion followed by the east and west directions. The North direction had the least expansion of built-up (31.70 percent). In the north direction, the built-up area increased from 186.11 hectares in 2001 to 245.1 hectares in 2021. The built-up in the east direction increased by 117.75 percent from 233.21 hectares in 2001 to 507.82 hectares in 2021 (Table-3). The significant reason for this increase in the east direction was the development of the residential area (Soma City and Alpha City), police line area, police station and bus stand.

Table-3: Directional Distribution of Built-up Expansion

Direction	Years			
	2001 (Area Ha)	2011 (Area Ha)	2021 (Area Ha)	2001-2021 Expansion (%)
North	186.11	204.85	245.10	31.70
East	233.21	373.14	507.82	117.75
South	181.33	225.08	523.19	188.53
West	348.22	381.42	525.06	50.78
Total	948.87	1184.49	1801.17	89.82

Source: Authors

The built-up area in the west direction increased by 50.78 percent from 348.22 hectares in 2001 to 525.06 hectares in 2021. In the west direction, major expansion occurred along the national highway (NH 9) that connects Fatehabad to Sirsa and Fatehabad-Bhatu Road. This expansion occurred in the form of residential colonies, factories and godowns. The south direction encountered with the maximum rise in built-up of 188.53 percent from 181.33 hectares in 2001 to 523.19 hectares in 2021. The national highway (NH 9) that connects Fatehabad to Hisar and Delhi played a significant role in the expansion of the built-up area in the south direction. It is also observed from the built-up expansion map (Fig. 2) that most of the built-up expansion occurred within a radius of 4 km from the city centre. This shows the edge expansion and continuous growth of the city.

Conclusion

Proactively addressing the possible loss of agricultural land is essential given Fatehabad's important location and growing population. Fatehabad, which is still in its nascent stages of development, presents an imminent challenge to its agricultural land due to increasing urbanization and population increase. The city's position as a mediator and its closeness to Sirsa and Hisar will probably spur further development and population expansion, combined with the rising demand for contemporary services, exacerbates the problem. To counteract the negative effects on agriculture, proactive actions are required. Fatehabad may achieve a healthy balance of urban growth and agricultural preservation by implementing comprehensive urban planning techniques, encouraging sustainable agricultural practices, and investing in infrastructural development. Failure to solve these concerns swiftly may have long-term ramifications for both the city's business and its environmental sustainability.

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A STUDY ON POTENTIAL OF TRIBAL TOURISM IN CHHATTISGARH AND ITS CHALLENGES

Sandesh Bandhu, Shivam Verma and Vishwambhar Nath Sharma

Abstract

Tribal tourism presents a viable avenue for the advancement of tribal communities. It offers an array of diverse economic, social, and cultural advantages. It provides income through the sale of handicrafts and guided tours. Tribal tourism can economically greatly aid in the development of indigenous communities. Direct and indirect income from these activities can lower poverty, increase job possibilities, and raise standards of living. The sales of tickets, entry fees, and service charges provide direct money to the tribal communities and in addition to the indirect income from the provision of lodging, food, and crafts made locally. The influx of funds supports public services and local infrastructure, so this economic boost goes beyond individual income and benefits the entire community. A part from this tribal tourism plays major role in social integration and cultural preservation of tribal communities. The present study has been done with reference to Chhattisgarh state which is famous for its rich tribal culture. Under this, the folk art and culture of the tribal society of Chhattisgarh has been discussed. Along with this, the possibilities of development of tribal tourism in the state and problems like Naxalism in the state have also been mentioned and G.I.S. techniques have been used for mapping of major tribal tourism circuits and Naxal affected districts of Chhattisgarh.

Introduction

Tribal tourism has drawn a lot of attention as a strategy for sustainable development. It entails traveling to indigenous communities and immersing oneself in their customs, culture, and way of life. This type of tourism is thought to be a potent instrument that can promote social integration, cultural preservation,

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and economic empowerment within native groups. Tribal tourism may help local economies by drawing visitors to these frequently isolated and underdeveloped areas, generating much-needed revenue and opening doors for locals to find work (Pratt et al., 2013). Tribal tourism also promotes a better knowledge and respect for indigenous cultures, which is essential for their preservation and upholding. Tribal tourism has the ability to significantly improve indigenous communities' economic standing, which is one of its main effects. Subsistence farming, hunting, and gathering are common traditional livelihoods in many tribal communities, but they are sometimes insufficient to support the population's economic demands, especially in light of current economic pressures and environmental issues. These communities can diversify their sources of revenue by developing an economy centered around tourism (Chouhan, 2022). There are several ways that tourism might generate income: guided tours, cultural events, selling handcrafted goods and artifacts, and charging admission to cultural places. In addition to giving community people direct financial support, these activities also have a positive indirect impact by boosting nearby companies that offer lodging, transportation, and food services. Another important economic benefit of tribal tourism is the creation of jobs. It generates indirect jobs in supporting industries like transportation, food production, and retail in addition to direct jobs in the tourism industry like tour guides, hospitality staff, and artisans (Chang et al., 2021). To make sure that community members can engage in and profit from the tourism business, training and capacity-building programs are crucial. These programs can impart skills in marketing, customer service, business administration, hospitality management, and other areas that are essential to the smooth functioning of tourism-related businesses (Burns & Figurova, 2007).

Study Region

Chhattisgarh is a landlocked state with a population of about 30 million, it is the seventeenth most populous state and the ninth largest in terms of area. Uttar Pradesh is to the north, Madhya Pradesh to the northwest, Maharashtra to the southwest, Jharkhand to the northeast, Odisha to the east, and Andhra Pradesh and Telangana to the south are its seven state borders. It was given statehood on November 1, 2000, when it was separated from Madhya Pradesh, with Raipur serving as the state capital. The state is hilly in the north and south, and fertile in the center. Roughly 44% of the state is covered by the deciduous woods of the Eastern Highlands woods.

Objectives

(1) To explain how tribal tourism affects the local economy, cultural sustainability and social integration.
(2) To explain rich tribal culture of Chhattisgarh.
(3) To describe government of India`s initiatives of tribal circuit development in Chhattisgarh under Swadesh darshan scheme.
(4) To analyze the problem of Naxalism as a challenge for tribal tourism development in Chhattisgarh.

Database and Methodology

This paper is based on literature review and some secondary data to provide a descriptive analysis and information about tribal tourism. Secondary sources included data from the Ministry of Tourism, Government of India, Ministry of Home Affairs, Census of India (2011), South Asian Terrorism Portal (S.A.T.P.) and Tribal research and training institute, Government of Chhattisgarh as well as scholarly publications, books, and reports on the effects of tribal tourism and Geospatial techniques have been used for mapping of major tribal tourism circuits and Naxal affected districts of Chhattisgarh.

Results and Discussion

Impact of Tribal Tourism on Local Economy, Cultural Sustainability and Social Integration

Tribe's economic situation can be changed by tribal tourism. Living conditions are enhanced and poverty is decreased through the creation of jobs in this field. Among the many important economic advantages of tribal tourism is income diversification. Tribal groups can become less depend on traditional means of subsistence like hunting and agriculture, which are frequently subject to environmental changes, by promoting tourism (Sankar & Mellalli, 2019). The community is better prepared to withstand economic shocks since tourism offers a more consistent and varied source of income. The local community benefits from the construction of tourism infrastructure, such as roads, communication systems, and medical facilities, in addition to tourists. Community members' quality of life is improved and vital services are more easily accessible with improved infrastructure. Infrastructure associated to tourism can be built, which can boost employment and the economy in related industries like building and transportation.

Further expanding and strengthening the local economy, better infrastructure can also support the growth of other economic ventures. One of the main advantages of tribal tourism is cultural sustainability (Verma & Murdia, 2017). It contributes to the preservation of indigenous heritage by fostering traditional knowledge and practices. Furthermore, it helps community members—especially the younger generation—develop a sense of cultural pride and identity. The sharing of information and skills between elder and younger generations is promoted by tribal tourism. The preservation of cultural heritage depends on this intergenerational dialogue. In order to preserve these customs, younger community members are inspired to pick up ancient crafts, dances, and ceremonies By promoting mutual respect and understanding between visitors and indigenous people, tribal tourism facilitates societal integration (Patil, 2017). It fosters chances for intercultural communication and exchange, which can strengthen social cohesiveness (Table-1). Tribal tourism contributes to reducing misconceptions and bridging cultural divides by introducing visitors to indigenous cultures. Promoting cultural understanding and tolerance is especially successful when done through educational tours and cultural immersion programs (Ahmed, 2020).

Table-1: Major Scheduled Tribes of Chhattisgarh (Top-10)

Sr. No.	Scheduled Tribe	Total Population	Rural Population	Urban Population
1	Gond, Arakh, Arrakh, Agaria, Asur, Bhatola, Maria etc.	4298404	3987170	311234
2	Kawar, Kanwar, Kaur, Cherwa, Rathia, Tanwar, Chattri	887477	840032	47445
3	Oraon, Dhanka, Dhangad	748789	659154	89635
4	Halba, Halbi	375182	324789	50393
5	Bhattra	213900	202531	11369
6	Sawar, Sawara	130709	118173	12536
7	Korwa, Kodaku	129429	125310	4119
8	Binjhwar	119718	113997	5721
9	Nagesia, Nagasia	114532	110745	3787
10	Bharia Bhumia, Bhuinhar Bhumia, Bhumiya, Bharia, Paliha, Pando	113967	108047	5920

Source: Authors

Rich Tribal Culture of Chhattisgar

Chhattisgarh is renowned for having a rich cultural legacy that embodies many facets of this beautiful state. The many traditional arts and crafts, tribal dances, folk music, local celebrations and fairs, and entertaining cultural events make up Chhattisgarh's cultural life. The majority population of Chhattisgarh is made up of tribal people who have simply and fervently kept their unique tribal culture. According to Census of India, 2011, the total population of Scheduled tribe in Chhattisgarh is 7822902, which is 30.60% of total population of the state. Oriya culture has also affected the eastern regions of the state of Chhattisgarh. The state's residents are traditional and adhere to a straightforward lifestyle based on their long-standing beliefs and practices. Their culinary habits, celebrations and fairs, clothing, decorations, traditional dancing, and music are all obvious examples of it. Every tribe in Chhattisgarh has a unique history and culture, resulting in a wide and diverse range of tribal cultures. The numerous styles of dancing, music, clothing, and cuisine are distinct from one another. The state of Chhattisgarh is home to a diverse range of tribes, including the Gond Maria, Muria, Dorla, and Baiga, all of whom are skilled craftspeople and dancers. So, it is very important to develop this new aspect of tourism in Chhattisgarh state because through this we can preserve rich tribal culture of the state and also show this culture to the modern world in a different way.

Scheduled Tribes in Chhattisgarh on Basis of Geographical Area

North Cultural Zone (Surguja Division)

This region includes tribes of Surguja, Surajpur, Balrampur, Korea, Jashpur districts and hill areas of Raigarh and Korba district. The major tribes of this region are Oraon, Kanwar, Munda, Nagesia, Korwa, Bhuinhar, Bhumia, Dhanwar, Saunta, Biar, Majhwar, Majhi, Kharia, Savra, Birhor, Kondh, Khairwar, Gond, Baiga and Agaria.

Central Cultural Zone (Bilaspur, Raipur and Durg Division)

In this region, the tribes of Bilaspur, Janjgir-Champa, Mungeli, Raigarh, Korba, Mahasamund, Raipur, Gariaband, Dhamtari, Durg, Balod, Rajnandgaon and Kabirdham etc are included. This area consists of flat plains, forest and hills. In this region Gond, Halba, Kanwar, Bhunjia, Agariya, Baiga, Kondh, Savra, Kanwar, Shikari pardhi, Binjhwar, Dhanwar, Saunta, Bhaina, Pardhan etc are inhabited.

Southern Cultural Zone (Bastar Division)

The region includes tribes of Dantewada, Bijapur, Sukma, Kondagaon, Bastar, Narayanpur and Kanker districts. This area is covered with dense forest and hills. The tribes like Halba, Abujhmadia, Gadba, Parja, Dorla, Bhatra, Muria, Madia, Gond etc reside in this area (Photo-1).

Famous Handicrafts of Chhattisgarh

Chhattisgarh has some unique kinds of handicrafts that are an integral part of the tradition of the state. Chhattisgarh handicrafts are well known in the country, especially the traditional bell metal, bamboo craft and the craft items made out of wood. The arts and crafts of Chhattisgarh truly represent the rich tribal culture of the state (Photo-1). This state is the place to behold the ancient as well as refined forms of arts and crafts. Some main examples are following-

(a) Bell Metal

Bell metal handicrafts are a prominent craft in the districts of Raigarh and Bastar in Chhattisgarh. Hollow casting or the lost wax method are used for this. This art form, also known as "Dokra" art, is primarily practiced by tribes like the "Ghadwas" of Bastar and the "Jharas" of Raigarh. Beeswax is the most crucial component used in the creation of the artifacts made using the dokra process, which also uses paddy husk, red soil, and cow dung.

(b) Iron Craft

The Kondagaon in Bastar is home to the ironsmiths, or lohars, who have been crafting iron for generations. They produce lamps, farm tools, and other household items.

(c) Wood Carving

Woodcraft is another kind of craft. Wood is used for a variety of purposes by the people of Chhattisgarh. For additional carpentry projects like object carving, they have begun utilizing wood. This craft is the specialty of a tribal community known as Badhais. It is an age-old craft in Chhattisgarh that is passed down from generation to generation. The Surguja and Raigarh districts are well known for it.

(d) Clay Pottery and Terracotta

Similar to several other states, Terracotta has made an appearance in Chhattisgarh tribal handicrafts. Terracotta pottery symbolizes the feelings of the

Bell Metal

Wood Carving

Clay Pottery

Tumba Craft

Tattoing or Godna

Fabrics of Chhattisgarh

Photo-1

tribes in the state as well as their customs and traditions. There are many terracotta statues in the Surguja and Bastar areas. The Bastar kumhars, or potters, use the soil of the Indravati River to fashion exquisite clay and terracotta sculptures.

(e) Tumba and Bamboo Craft

It is less known craft and widely produced in the Bastar region. The origin of Tumba craft lies in the widespread use of hollow gourd shells as containers by the tribals to store water and salfi. Bamboo is abundantly found in the forests of Chhattisgarh and thus it is put in variety of use by the tribals. The practical importance of the bamboo crafts produced by the Chhattisgarhi people is widely recognized. Among the products created by the Bastar tribe are beautiful furniture, mats, baskets, home and office utilities, and utilities. The districts of Narayanpur, Bastar, Bilaspur, and Gariyabandh in the state are centers for the practice of the bamboo craft.

Fabrics of Chhattisgarh

In Chhattisgarh, silk weaving is the primary handloom sector. This is the territory of Kosa, sometimes called Tussar. Mostly, Raigarh and Champa are where one may find this Silk. Both `lost wax art` and `kosa` silk are well-known products of Chhattisgarh. Kosa is produced in part thanks to Chhattisgarh's forest. The cocoons of sal, saja, or arjun trees are used to make it.

Tattoing or Godna

The tattoos hold social significance for the tribal people of Chhattisgarh. Thus, they widely engage in this tattooing practice, which begins at the young age of 7 and lasts until marriage title in a status. It is a reflection of their group quotes and offers them security because they believe that tattoos are the only items a woman can take with her when she passes away and carry it with her into the afterlife. The art and artists of Godna have been greatly impacted by modernity. Ink has moved from the body to paper, fabric, and canvas. Through workshops and exhibitions, female tattoo artists have significantly contributed to the spread of Godna painting throughout India and elsewhere.

Tribal population is 8.6% of the total population in India and they are present in different parts of the country (Fig. 1). They have their own customs and traditions. Tribal society always lives in the lap of nature, so their habitat is naturally very attractive, along with this, their folk art and culture also attract the general public a lot. Keeping this in mind, the Tourism Department of the Government of India

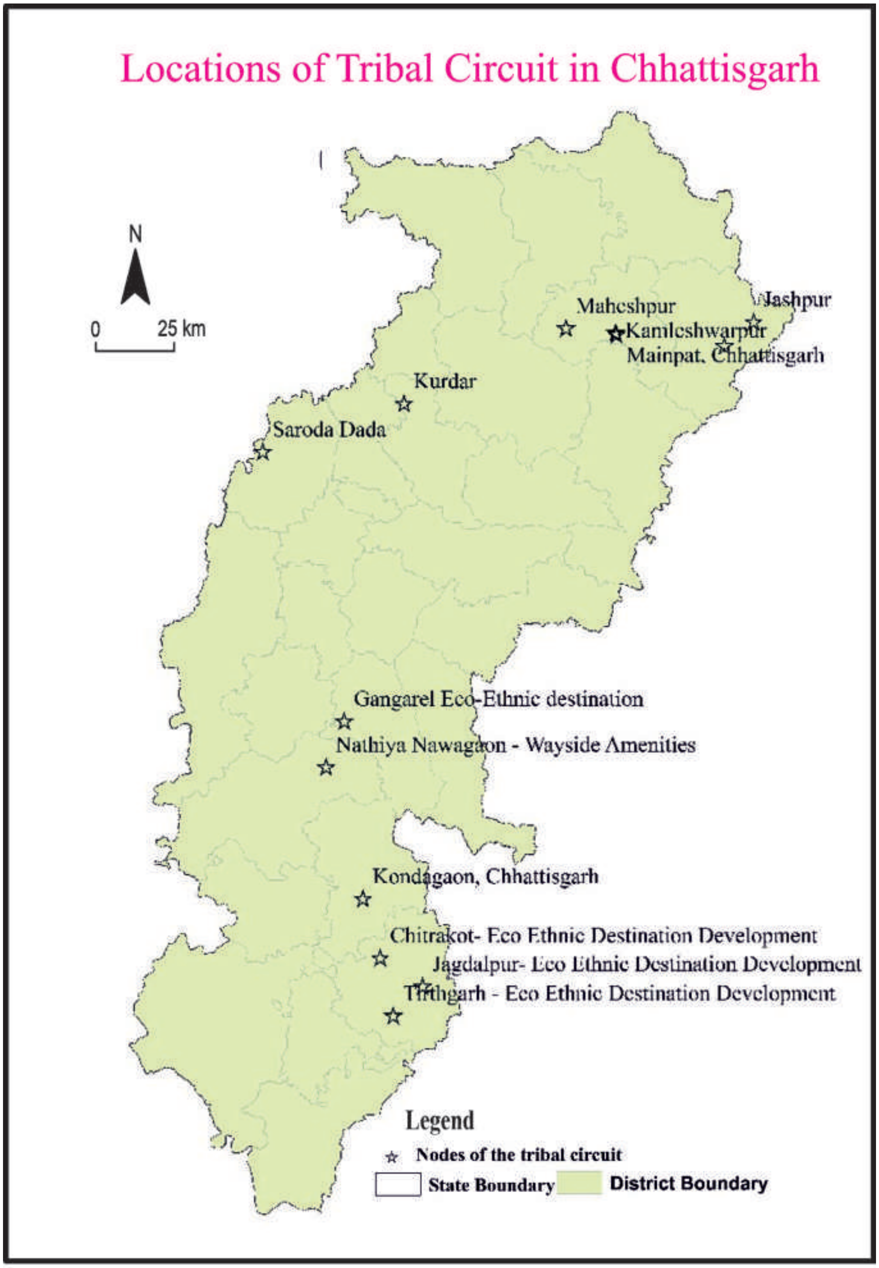
Locations of Tribal Circuit in Chhattisgarh
N
0 25 km
Maheshpur
Jashpur
Kamleshwarpur
Mainpat, Chhattisgarh
Kurdar
Saroda Dada
Gangarel Eco-Ethnic destination
Nathiya Nawagaon - Wayside Amenities
Kondagaon, Chhattisgarh
Chitrakot- Eco Ethnic Destination Development
Jagdalpur- Eco Ethnic Destination Development
Tirthgarh - Eco Ethnic Destination Development
Legend
Nodes of the tribal circuit
State Boundary
District Boundary

Fig. 1

has also given priority to the development of tribal circuits under the Swadesh Darshan Yojana. Tribal tourism is a completely new type of tourism, so initially it has been started in only 3 states Chhattisgarh, Telangana and Nagaland. Out of these, it has started first from Chhattisgarh. Chhattisgarh is a tribal dominated state with around 30% population coming from scheduled tribes. Hence there are immense possibilities for the development of this type of tourism (Fig. 1). Here, Jashpur, Kunkuri, Manipat, Kamleshpur, Maheshpur, Kurdar, Saroda dadar, Gangrel, Kondagaon, Nathia nawagaon, Jagdalpur, Chitrakoot, Tirthgarh places have been selected for the development of tribal circuits. This is also shown in Table-2.

Table-2: Tribal Circuit and Projects in Chhatisgarh

State	Year	Name of the Circuit	Name of the Project	Sanctioned (in crores)
Chhattisgarh	2015-16	Tribal Circuit	Development of Jashpur-Kunkuri- Mainpat-Kamleshpur - Maheshpur -Kurdar - Sarodhadadar-Gangrel- Kondagaon–Nathiyanawagaon-Jagdalpur- Chitrakoot-Tirthgarh	96.1

Source: https://data.gov.in/resource/year-wise-details-projects-sanctioned-ministry-under-tribal-circuit-theme-swadesh-darshan

Note: These responses have been taken from the Baiga tribal community of Singrauli district, Madhya Pradesh during a pilot survey. The main aim to add this data here is to understand tribal community`s thinking towards tribal tourism. Although this area is different but we can understand the thinking of tribal communities.)

A pilot survey has been done with sample size of 100 persons of Baiga tribal community in Waidhan, Chitarangi and Deosar blocks of Singrauli district to understand the thinking of the tribal community towards tribal tourism. At the end of survey, we found that 60% persons were agree with this kind of tourism, 30% were disagree due to some concerns like mix of culture, overcrowding, loss of cultural identity and exploitation and 10% give mixed answers. So, it is clear that tribal tourism is important but government should also keep in mind all these concerns (Fig. 2).

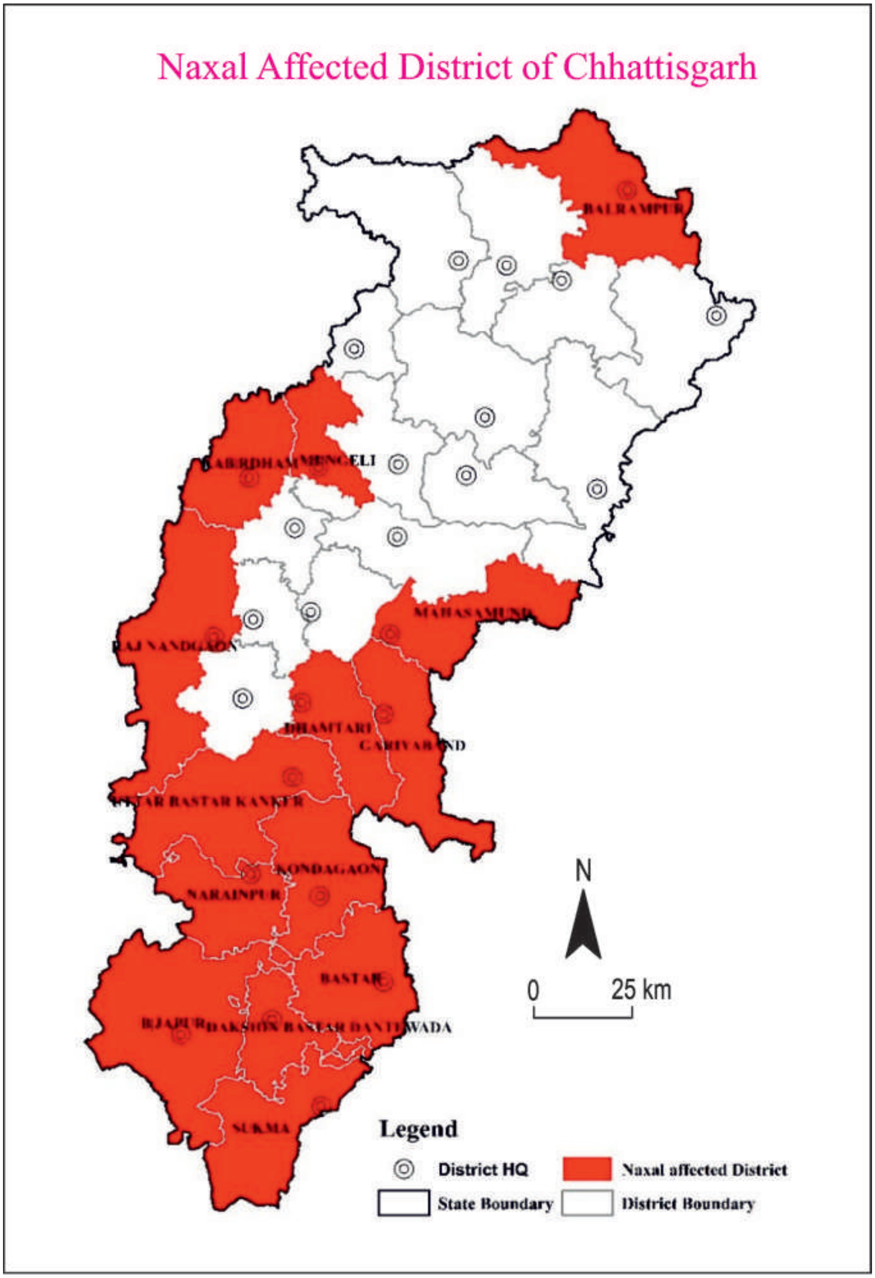
Naxal Affected District of Chhattisgarh
BALRAMPUR
MAHASAMUND
DHAMTARI
KONDAGAON
NARAINPUR
BASTAR
SUKMA
N
0
25 km
Legend
District HQ
Naxal affected District
State Boundary
District Boundary

Fig. 2

Problem of Naxalism as a challenge for tribal tourism development in Chhattisgarh

At present, Naxalism remains a big problem for Chhattisgarh. According to the data of the Ministry of Home Affairs of 2021-22 in Chhattisgarh (Fig. 2), a total of 14 districts are included under the Security related expenditure (S.R.E.) scheme, which are Naxal-affected. Balrampur, Kabirdham, Mungeli, Mahasamund, Gariaband, Rajnandgaon, Kanker, Kondagaon, Narayanpur, Bastar, Bijapur, Dantewada and Sukma districts are included, which are shown in Map 2. By analyzing the data of deaths due to Naxalism, then the top 5 districts are Dantewada, Bijapur, Sukma, Bastar and Narayanpur, where the total deaths from year 2000-2020 are 1140, 758, 425, 216, 204 respectively and it has been shown in Graph 1. Due to this kind of situation, tourism is badly affected because most of the tribal tourism locations are situated in these areas.

Conclusion

On the basis of above description, it is clear that Chhattisgarh has immense potential for the development of tribal tourism because it is tribal rich state and also rich in natural beauty. Bell metal, Iron craft, Wood carving, Clay pottery, Terracotta, Tumba craft, Bamboo craft, Kosa silk and Godna (Tattoo) are speciality of rich tribal culture of the state. Here tribal tourism can be developed with eco-tourism, agro tourism and rural tourism but due to some problems specially like Naxalism, this state is not doing so well as per its potential. Although in recent years, government`s work is also commendable in reducing red corridor of Chhattisgarh but this problem still exists and it is main reason for present condition of the state. The state is growing day by day but not as per its capability. In future there is immense potential for the development of Chhattisgarh.

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DEMOGRAPHY AND SOCIO-ECONOMIC DISPARITIES IN AYODHYA DISTRICT: A COMPARATIVE TEMPORAL ANALYSIS

Gaurav Yadav and Dr. Pranay Kant Biswas

Abstract

This research paper focuses on the trends and patterns of population structure in Ayodhya district during the time period of 1990-2020 to find out the dynamics of population structure. During the recent decades, some changes are taking place in population structure in India, both in rural as well as in urban areas. Trends and pattern in population structure varies in rural or in urban areas, which are being governed by socio-economic development, level of literacy rate, types of employment opportunities and occupational structure, trends in male-female population, level of female education and women empowerment and cultural background. Such contemporary dynamic transformation of population structure would tell us about the changing trends in different components of population structure. Main emphasize in this study is on trends in changing population structure, factors affecting to these changes, relationship between changing population structure and issues and challenges taking place due to changing population structure and increasing inequalities.

Introduction

Population structure is an important part of demography and of population geography, which explain the nature of population and its dynamics in any geographic unit on this planet earth. It tells us about the demography and its components existing on any part of the earth surface. Population structure also throw light on the future trends of population of any area, such as structure based on age, gender, occupational structure and about possible future changes likely to be taken place in working population, male-female structure and age based structure, and about possible future challenges to be existed to tackle the problem of population and occupational and gender structure on any part of the planet earth.

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So population structure will play important role for policy makers, environmental planners, managers, disaster risk management, decision makers and urban planners. Taking it into consideration present study have been initiated to study the population structure and its dynamics in Ayodhya district of Uttar Pradesh.

Study Region

Ayodhya, formerly known as "Faizabad" is one of the district of Uttar Pradesh state of India. This district comprised of 5 tehsils and 1272 villages. There are 10 towns in Ayodhya district. Ayodhya district spreads in 2522 sq. km area. According to census of India, 2011, total population of Ayodhya was 2470996 persons. Among them 1259628 were male and 1211368 were females. City of Ayodhya is serving as its administrative headquarter. It is also serving as headquarter of Ayodhya division. The city of Ayodhya is also of great religious importance as it is considering as birth place of lord Rama and known for mighty lord Rama temple to be constructed. It was also to be used as capital of ancient kingdom of Kosala kingdom. Ayodhya district is located on the banks of holy river Saryu. Ayodhya district is located on Balrampur- Prayagraj road. Ayodhya district is 130 kilometers far away from the Lucknow, the state capital, 200 kilometers from Varanasi, 160 kilometers from Prayagraj, 140 kilometers from Gorakhpur, and about 336 kilometers from Delhi, the national capital. Ayodhya district is also connected with other parts of the state as well as with other parts of the country by network of Indian railway. Economy of the Ayodhya district is mainly agrarian but in addition the district is also becomes center of medium and small-scale enterprises as well.

Objectives

(1) To study the nature of different components of population structure.
(2) To assess the trends in inequalities among various components of population structure.

Database and Methodology

For the present study data regarding different components of population structure has been obtained from the census of India and statistical abstract of Uttar Pradesh and district census handbook Ayodhya district 1981, 1991, 2001, and 2011. The data obtained from the sources have been analyzed through some statistical techniques, decadal growth rate annual exponential growth rate have been assessed to show the trends, patterns, variations in population structure during the selected time period in the Ayodhya district, relationship between population structure and inequalities has been done with statistical methods of correlation and regression. Diagrams and graphs have also been prepared to represent the scenario of population structure clearly and in easy and simple way.

Result and Discussion

Decadal Variations in Total Population (1971-2011)

Population is an important ingredient of any nation, state, district, region and village, because development of socio-economic land scape of any region directly or indirectly connects with population. Existence of population in any region paved way for the development, as determine the needs, possibility, opportunity and potential of any region, any plan to be harnessed by implementation of any plan meant for development of particular region and population also provide the human resource and man power for the planning, designing, coordinating and implementing of that plan (Table-1).

Table-1: Decadal Variations in Total Population (1971-2011)

Year	Total Population	Decadal variations	%age
1971	1927281		
1981	2382515	455234	23.61
1991	1684747	697768	23.71
2001	2088928	404181	23.99
2011	2470996	382068	18.29

Source: Census of India, 1971, 1981, 1991, 2001 and 2011

Taking it into consideration the analysis of dynamics of population in Ayodhya district during the time period of 1971-2011 has been chosen for the present study. If we talk about the population dynamics in Ayodhya district it presents interesting facts about the population in the district (Table-1). Total population in Ayodhya district was 1927281 persons in 1971, which increased to 2382515 persons in 1981, 1684747 persons in 1991, 2088928 persons in 2001 and 2470996 in 2011. According the data given table given below population is increasing in the district. During the decade of 1971-1981 decadal variations in the district were observed as 455234 were more added in total population in the district which was 23.61 percent. It means district witnessed an increase in 23.61 percent in population during that decade. During the decade of 1981-1991, decadal variations in terms of 697768 persons were recorded which was 23.71 percent, which was little greater than which it was during the decade of 1971-1981. Decadal variations in population, during the decade of 1991-2001, were recorded as 404181 persons in total population, which was 23.99. During the decade of 2001-2011 decadal variations were recorded minimu7m, which was 382068, which was 18.29 percent. It means there is declining trends in decadal variations in population of district, probably due to expanding education, spreading awareness about population control and government initiatives to population control.

Decadal Variations in Population based on Male-Females (1971-2011)

The male population and female population are two important components of population structure of any country, region, state, district or village, which tells us about the inter play of human beings on earth surface. It also tells about the inequalities and disparities in human population, in this way distribution of male and female population guide to the policy makers, executives of planning process, and health professional to provide health services and requirement and potentiality for any health and other projects for socio-economic development of that region (table-2). Taking it into consideration analysis of the nature of population structure based on male and female population has been chosen for this study. According to the table given below total male population was 1160999 in Ayodhya district in 1971, which increased to 1231755 in 1981. In 1991 there was decline in male population, as male population was recorded as 887574, which again shown an increase as it was recorded as 1077472 in 2001, which again shown increasing trends as it was recorded as 1259628 in 2011.

Table-2: Decadal Variations in Population based on Male-Females (1971-2011)

Year	Male Population	Female Population	Variation
1971	1160999	766282	394717
1981	1231755	1150760	80990
1991	887574	797173	90401
2001	1077472	1011456	66016
2011	1259628	1211368	48260

Source: Census of India, 1971, 1981, 1991, 2001 and 2011

If we talk about the female component of population structure, it shows ups and downs in decadal population of females in the district. According to the following table total population the district was recorded as 766282 in

1971, which increased to 1150760 in 1981, which comes down to 797173 in 1991. In 2001, an increase in female population was observed in the district as female population was recorded as 1011456, which shows a slight increase to 1211368 in 2011 (Table-2 and Fig. 1).

If we have to talk about the variations in fame and female population in the study area than we can see a continual decline in variations in male-female population in the study area. In 1971 variation in male-female population was recoded as 394717, which was maximum till the date, variation in male-female population comes down to 80990 in 1981, which again increased to 90401 in 1991. Variation in male-female population was recorded as 66016 in 2001, which again decreased to 48260 in 2011. After studying the whole phenomenon of male-female population in the study area, we can say that decadal variations in male-female population going to be decline in continual manner due to expanding education, and due to awareness about the importance of female population.

Trends in Population: Infant Mortality Rate and Child Mortality Rate

Infant mortality and child mortality are two important components of demographic landscape of any country, region, state, district or village, which tells us about the level of physical well-being of population, level of available health facilities and availability of nutritious diet, and tells about the needs and requirement for nutritious diet and of expansion of health facilities, at the time of birth of a child and health services to be provide after birth of the child, in this way it helps to the demographers, policy makers and experts working in health and family welfare sectors. It also tells about the future trends in human population, and future health well-being of population of any region, in this way distribution of infant mortality and child mortality in any area guide to the policy makers, executives of planning process, and health professional to provide health services and requirement and potentiality for any health and other projects for socio-economic development of that region (Fig. 1 and Table-3).

Taking it into consideration analysis of the nature of population structure based on infant rate and child mortality rate in male and female population has been chosen for this study. According to the table number 3, infant mortality rate among new born male was recorded as 132 per 1000 new born male infants in Ayodhya district in 1971, which declined to 125 per 1000 new born infants in 1981. Infant mortality rate was observed as 120 per 1000 new born male infants in 1991.

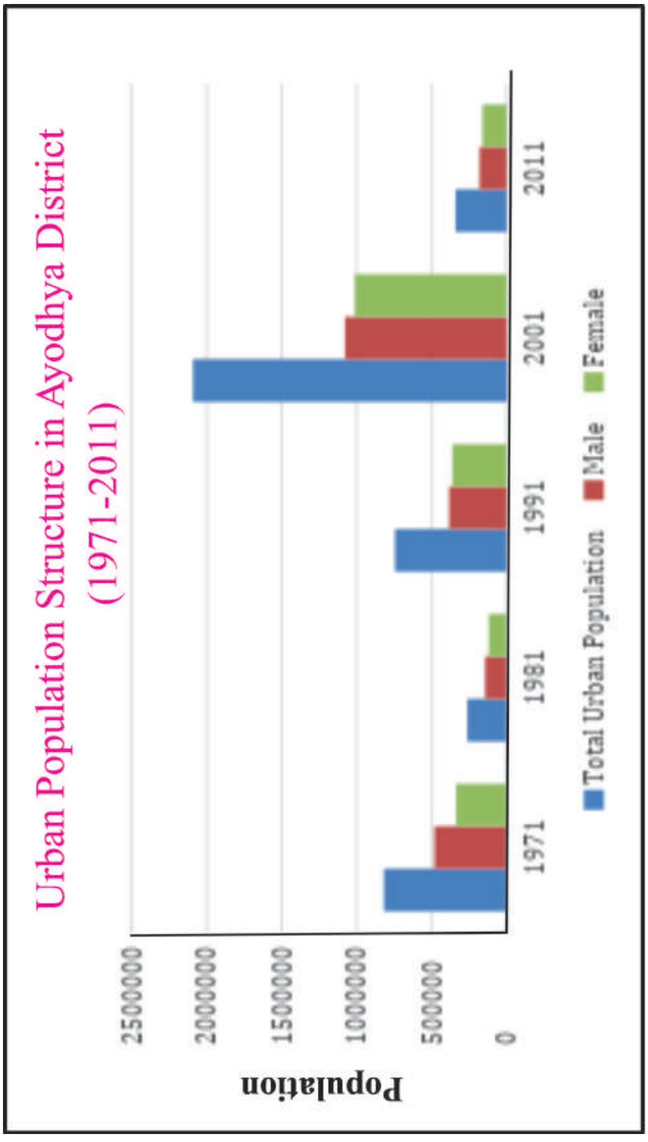
Urban Population Structure in Ayodhya District
(1971-2011)
Population
2500000
2000000
1500000
1000000
500000
0
1971
1981
1991
2001
2011
Total Urban Population
Male
Female

Fig. 1

Table-3: Infant Mortality Rate and Child Mortality Rate in Ayodhya District during 1971-2011

Year	Infant mortality Rate			Child mortality Rate		
	Male	Female	Aggregate mortality rate	Male	Female	Aggregate child mortality rate
1971	132	115	120	185	239	195
1981	125	104	116	173	207	187
1991	120	102	110	167	199	185
2001	110	100	105	160	180	178
2011	55	57	94	60	62	124

Source: Census of India, 1971, 1981, 1991, 2001 and 2011

In 2001 there was observed again a decline in male infant mortality rate, as male infant mortality rate was recorded as 110, which again shown a decline in 2011 as it was recorded as 55 per 1000 new born male infants in 2011. If we talk about the trends in infant mortality rate in female new born infants in the study area, then it also showing a declining trends, which suggest there is declining trend in inequalities among male-female population in the study area. In 1971 infant mortality rate among new born female infants was recorded as 115 per 1000 new born female infants in Ayodhya district, which declined to 104 per 1000 new born female infants in 1981. Female infant mortality rate was observed as 102 per 1000 new born female infants in 1991. In 2001 decline was observed again in female infant mortality rate, as female infant mortality rate was recorded as 100, which again shown a decline in 2011 as it was recorded as 57 per 1000 new born female infants in 2011.

In terms of aggregate infant mortality rate in the study area, it was observed as 120 per 1000 new born infants in the district in 1971, which decreased to 116 per 1000 new born infants in 1981, 110 per 1000 new born infants in 1991, 105 per 1000 new born infants in 2001 and 94 per 1000 new born infants in 2011. If we talk about the trends in child mortality rate in the study area, then it was recorded as, 185 male children per 1000 living male children and 239 female children per 1000 living female children in 1971 in Ayodhya district, which came down to 173 male children per 1000 living male children, and 207 female children per 1000 living female children in 1981. Child mortality rate in Ayodhya district was recorded as 167 male children per 1000 living male children and 199 female children per 1000 living female children in 1991, 160 male children per 1000 living male children, and 180 female children per 1000 living female children in 2001, and 60 male children per 1000 living male children and 62 female children per 1000 living female children in 2011. In terms of aggregate child mortality rate in Ayodhya district it was recorded as 195 deaths of children per 1000 living children in 1971, which was 187 per 1000 in 1981, 185 per 1000 in 1991, 178 per 1000 in 2001 and 124 per 1000 in 2011. If we talk about the trends in child mortality rate, both for male-female and aggregate child mortality rate in the study area during the time period of 1971-2011, then it showing a declining trend, which suggest there is declining trend in inequalities among male-female population in the study area and there is expansion of health facilities for the children and families also got awareness about the health of their children.

Trends in Population Structure based of Rural-urban Population

The major chunk of population in India lives in rural areas, and population settlement has been divided into rural or urban, and affect the cultural, social and economic set up of the area, so in order to understand the distribution of population in rural-urban population and pattern and trends of population structure in rural urban area analysis of population structure in rural and area has been chosen. If we discuss about the trends in rural and urban population in Ayodhya district, then rural and urban population shown a fluctuating trends during the time period of 1971-2011 (Table-4). In urban population number of male persons in 1971 was recorded as 48046 males, which was fluctuated to 143085 persons in 1981, which increased to 382982 persons in 1991, which increased to 1077472 persons in 2001 and 180371 in 2011.

Table-4: Trends in Population Structure based in Rural and Urban Population during 1971-2011

Year	Urban Population			Rural Population			Total Population in District
	Male	Female	Total Urban	Male	Female	Total Rural	
1971	480486	336569	817055	680513	429713	1110226	1927281
1981	143085	118114	261199	1088670	1032646	2121316	2382515
1991	382982	360857	743839	504592	436316	940908	1684747
2001	1077472	1011456	2088928	925443	882212	1807655	3896583
2011	180371	159882	340253	1079257	1051486	2130743	2470996

Source: Census of India, 1971, 1981, 1991, 2001 and 2011

If we talk about the number of the female population in urban areas in Ayodhya district then just like the male population, female population also fluctuated from decade to decade. It was recorded as 336569 females in 1971, which came down to 118114 in 1981, which again increased to 360857 in 1991. Number of females in urban population of Ayodhya district was recorded as 1011456 in 2001, which decreased to 159882 in 2011. In case of total urban population of Ayodhya district, it was recorded as 817055 in 1971, which came down to 261199 in 1981, it increased to 743839 in 1991, number of urban populations was recorded as 2088928 in 2001, which increased to 340253 persons in 2011. After observing the above given table, we can say that number of male and females in urban population as well as total urban population shows a fluctuation from one decade to another decade. If we talk about the trends in rural population in Ayodhya district, then it is increasing decade by decade in the district, which is clear from the Table-4. According to this table number of males in the study area were recorded as 680513 in 1971, which increased to 1088670 persons in 1981, which decreased to 504592 persons in 1991, which further increased to 925443 persons in 2001 and 1079257 in 2011. If we talk about the number of the female population in rural areas in Ayodhya district then just like the male population, female population also increasing from decade to decade. It was recorded as 429713 females in 1971, which increased to 1032646 in 1981, which decreased to 436316 in 1991. Number of females in rural population of Ayodhya district was recorded as 882212 in 2001, which increased to 1051486 in 2011. In case of total rural population of Ayodhya district it was recorded as 1110226 in 1971, which increased to 2121316 in 1981, it decreased to 940908 in 1991, number of rural population was recorded as 1807655 in 2001, which increased to 2130743 persons in 2011. After observing the above given table we can say that number of male and females in rural population as well as total rural population shows an increasing trend from one decade to another decade.

Population Structure on the Basis of Literacy Rate

As we know that literacy and education is an important demographic component of population of any region as it gives us an idea about the level of intellectual development, level of modernization, readiness to adopt new values and norms and readiness to reject old out dated traditional rituals, thoughts and customs of any region, and level of socio-economic, development of population of any region. Expansion of education leads to expansion of new technologies and innovations, raise in standard of living. Possible future nature of population, structure of future population and structure of future working population, structure of socio-economic, cultural and political set up of the region are determined by education (Fig. 2). Structure of literate population of any region also tells us about the future structure of male-female population, equalities and inequalities, future potential of population and possibility of existing of disparities in male-female population. Structure of population on the basis of literate population also tells us about the level of intellectual development of the society, change in mindset of the population about female children, modernization of mindset of population.

Table-5: Trends in Population based on Literate Population (1971-2011)

Year	Literate Persons in Urban Area			Literate Persons in Rural Area			Total Literate Population in District
	Male	Female	Total Literate in Urban Area	Male	Female	Total Literate in Rural Area	
1971	81192	40981	122173	370972	99976	470948	593121
1981	83469	42771	126240	386878	97002	483880	610120
1991	89598	52980	142578	394679	110965	505644	648222
2001	106601	73350	179951	504850	275560	780410	960361
2011	135267	106305	241572	703072	506257	1209329	1450901

Source: Census of India, 1971, 1981, 1991, 2001 and 2011

Taking it into consideration, analysis of population structure based on population of literates and structure of male and female literate population in rural and urban population has been chosen for the present study. If we discussed about the population structure on the basis of number of literates in rural or urban population in Ayodhya district, then it shows a increasing trends in terms of number of male-female literates and in total population of literates in the study area during the time period of 1971- 2011. Number of male literates in urban population of Ayodhya was recorded as 81192 in 1971, which increased to 83469 in 1981. It again increased to 89598 in 1991, 106601 in 2001 and 135267 in 2011. In case of number of female literates in urban population was recorded as 40981 in 1971, which increased to 42771 in 1981. It again increased to 52980 in 1991, 73350 in 2001 and 106305 in 2011. In case of total literates in urban population, it was recorded as 122173 in 1971, which increased to 126240 in 1981, 142578 in 1991, 179951 in 2001 and 241572 in 2011. If we talk about the number of literate population in rural population in Ayodhya district then number of male literates in rural population

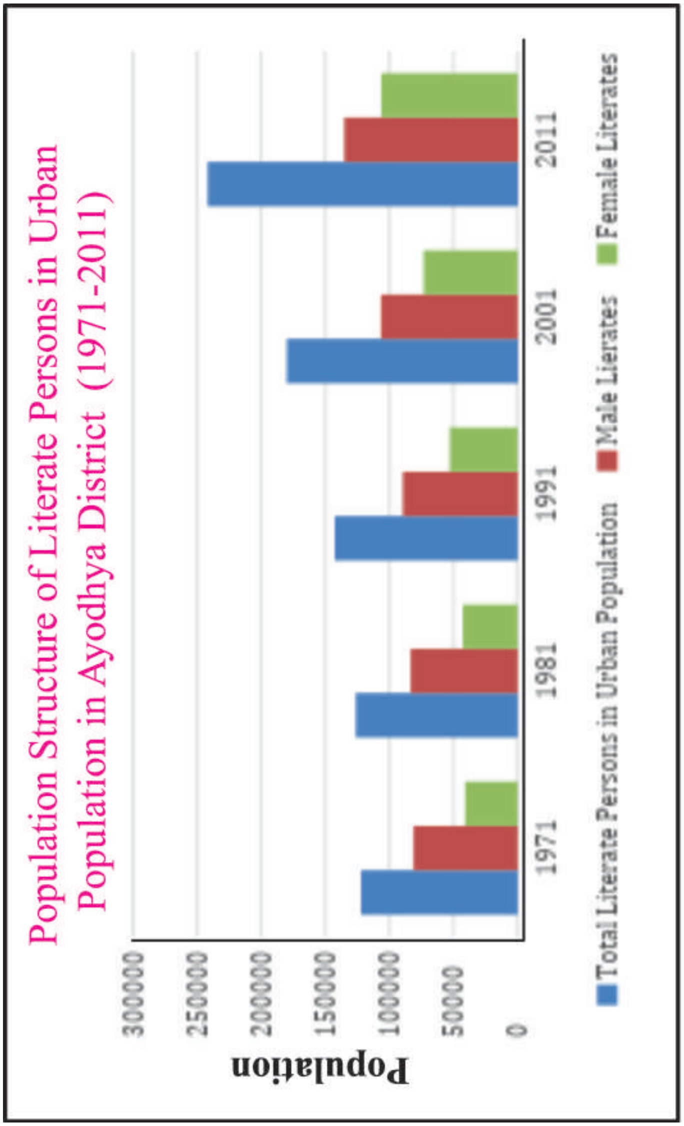
Population Structure of Literate Persons in Urban Population in Ayodhya District (1971-2011)
Population
300000
250000
200000
150000
100000
50000
0
1971
1981
1991
2001
2011
Total Literate Persons in Urban Population
Male Lierates
Female Literates

Fig. 2

of Ayodhya was recorded as 370972 in 1971, which increased to 386878 in 1981. It again increased to 394679 in 1991, 504850 in 2001 and 703072 in 2011. In case of number of female literates in rural population of the study area then, it was recorded as 99976 in 1971, which shows minor decline to 97002 in 1981. It again increased to 110965 in 1991, 275560 in 2001 and 506257 in 2011. In case of total number of literates in rural population in the study area, it was recorded as 470948 in 1971, which increased to 483880 in 1981, 505644 in 1991, 780410 in 2001 and 1209329 in 2011. In case of total number of literates in population of the study area, it was recorded as 593121 in 1971, which increased to 610120 in 1981, 648222 in 1991, 960361 in 2001 and 1450901 in 2011.

Factor Affecting Population Structure in Ayodhya District

We have observed changing trends in population structure in Ayodhya district of Uttar Pradesh during the time period of 1970-2011. These changes are induced by a lot of factors, which affect the population structure in directly or indirectly, positively or negatively. All these factors which affect the population structure can be discussed as below:

Expansion of Education

As we know that education is a powerful weapon of social change, so expansion of education leads to bring social change and paves the way for social reforms. So as the education is expanding, the mindset and thinking of the society changes, and people realized the importance of small family norms, importance of women empowerment and importance of girl child, due to which female infanticide, and mass illiteracy among women folk and inequalities in male-female ratio and inequalities in male-female education tends to decline in Ayodhya district. Due to expansion of education peoples approach towards occupation and about economy changes, now people getting involved in other sectors of economy due to which occupation structure changes and due to education women started to come out of the boundary of the house and shown courage to choose other occupation, which were reserved for males in traditional patriarchal system. Finally, it can be said that the expansion of education in the district play major role in changing the population structure in the study area.

Economic Development

Economic development also poses some impacts on nature of population structure directly or indirectly. Areas having well developed or diversified economy have different types of population structure. Population structure varies from the area where there is little economic development or economy is less diversifies, from the areas which have well developed or well diverse economy. In areas having less diversify traditional agrarian economy, economic development is less and population structure shows a lot of disparities in terms of male-female ration, level of educational development. On the other hand, areas of well diverse modern industrial economy, have fully developed economy, due to which, the level of educational development, and male-female disparities comes down. Changing population structure in urban area and in rural area proved the importance of economic development in bringing changes in population structure in the study area.

Expansion of Health Facilities

Expansion of health facilities and access to health facilities also affect the population structure in any part of the earth surface. Level of health facilities, access to these health facilities and nearness to these health facilities and modernization of these health facilities play major role in changing population structure, as availability and effectiveness of health facilities improve the health of the target population, due to working and living capabilities of population got improved and as there is decline in death rate of new born infants both male and females infants and decrease in death rate of male-female children of age group of 0-6 years there is increase in population due to population structure changes. Similarly expanding and fully developed health facilities leads to decrease in death rate of elder people and due to which there is increase in population of elder peoples.

Level of Urbanization

Level of urbanization also affect the population, as the process of urbanization leads to changes in level of thinking, psychological and sociological mindset of people about education, health and about the status and importance of females kids and their education and easily access to educational and health facilities the level of literacy rate, male-female population, participation of population in various sector of economy, due to which population structure of male-female population, level of education of both male-female improved and population structure of working or non-working male-female got improved. As people in rural area mainly bound to the traditional thinking so level of education, level of working, non-working population of male-female population and monopoly of agricultural economy leads to a lot of variations in population structure of rural area.

Role of Government Agencies, Non-government Organizations and Government Policies

Government agencies such as health and family welfare department, women and child welfare department, health department, Non-government organizations, educational department and their policies related to population control, family welfare, improvement of health and working capabilities, economic well-being of population, population control, improvement of sex ratio and improvement of education of female kids and prevention of female infanticide, women empowerment, generation of employment, etc. play their role in order to bring changes in population structure.

Changing Belief System and Modernization

Changing belief system about small family norms, women empowerment, importance of female kids and importance of health and importance of education due to expansion of education and health facilities. Now people rejecting old and narrow minded belief system, and accepting new norms, modern thinking, modern ideas about female kids, modernization of belief system leads to changes in population structure in terms of male-female population, health and education of female and population structure of working non-working male-female.

Conclusion

After above given discussion, it can be concluded that," the total population in Ayodhya district is increasing decade by decade, though the decadal variations in population growth shown a declining trend. Similarly, population of male and females shown a rising trend but rate of increasing varies in male and female population growth. Infant mortality rate, male infant mortality rate, female infant mortality rate, child mortality rate, male child mortality rate and female child mortality rate shown a declining trend in the study area, which is resulted due to increasing literacy rate in the study area, which leads to increasing awareness about the importance of healthcare of infants and child, which leads to decline in death rate of infants and child mortality rate. Number of male and female persons in urban population and total urban population showing a declining trend but number of male and females persons and total rural population showing a increasing trend, in other words share of rural population in total population of the district increased during the time period of 1971-2011. Number of children under age group of 0-6 years declining both in rural as well as in urban areas, though it decreasing in urban population at greater rate than in rural population. Number of literate persons both male and females is increasing in the study area. Population working in Ayodhya district showing a increasing trends, though the number of working male and females variates from each other, on the other non-working population shows a decreasing trends.

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RAINFALL PATTERN VARIABILITY IN HAORA RIVER BASIN, TRIPURA, INDIA

Bindia Debbarma and Eahya Al Huda

Abstract

Rainfall stands as the most vital climatic factor influencing both ecosystems and human societies. It plays a crucial role in not only providing the necessary water for plant growth but also affects the overall health and sustainability of various ecosystems. Within specific physiographic and climatic regions, catchments demonstrate notable differences in their hydrological responses to rainfall inputs. These differences can be attributed to interplay of spatial variability in catchment characteristics, such as topography, soil type, and land use, alongside the variability of rainfall amounts and patterns. Focusing on the region of Tripura, which is situated under the Tropic of Cancer at approximately 23.5° N latitude, the region's geographical positioning contributes to its tropical climate, significantly impacting its hydrological cycles. The annual rainfall in Tripura ranges from an impressive 1,619.30 mm to as much as 2,985.10 mm, showcasing the wide variability typical of tropical climates. To better understand the implications of this variability, a detailed analysis was conducted using a long-term precipitation dataset spanning ten years, from 2009 to 2018, focused on the Haora River Basin. This dataset serves as a foundation for assessing rainfall variability through specific statistical methods that evaluate both annual and seasonal changes. The results of this study have revealed a striking increase in annual rainfall variation over the observed period, with figures rising from 149.98% to 174.40%. Such variability in annual rainfall can lead to significant changes in the quantities and frequencies of rainfall, which in turn has a direct impact on stream flow patterns and the spatio-temporal distribution of runoff, groundwater reserves, and soil moisture within the basin. Understanding these fluctuations and trends in long-term hydrological and climatological data is essential for developing effective climate change mitigation and adaptation strategies, ultimately aiming to enhance resilience in both natural and human systems.

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Addressing these challenges requires a comprehensive approach that acknowledges the complex interplay between rainfall, ecosystems, and human activities.

Introduction

Rainfall is the main constitute for the existence of drainage basin which deals with the occurrence, movement, and availability of water (Carlston, 1963). It is generally accepted that within particular physiographic and climatic regions, catchments exhibit differences in their hydrological response. These differences result from the interaction of spatial variability in catchment characteristics and variability of rainfall inputs (Beven, 2012).Thus, the detection of trends and variations in long hydro climatological series is relevant for climate change mitigation and adaptation strategies (Aoula et al., 2021). Heavy rainfall is one of the main triggering factors for natural hazards in the region, it is often accompanied by cloudbursts that aggravate the flood situation in the entire area, which can have devastating impacts on human communities and infrastructure (Gupta et al., 2013). During the rainy season, landslides are frequently causing extensive damage to the surrounding areas(Joshi et al., 2013).Natural systems and human activities in Morocco are most at risk due to lack of regular water supply during the years from 1980 to 1985 and from 1991 to 1995. This is due to the high inter-annual variability and the significant seasonality of rainfall. (Aoula et al., 2021). Rainfall is also a significant factor in shaping the Earth's landscape. Through the process of erosion and deposition, rainfall helps to create and modify landforms, including valleys, canyons, and river deltas (Harris et al., 2004). Many plant species rely on rainfall to survive, and changes in rainfall patterns can have significant impacts on ecosystem health (Baker et al., 2013). The monsoon rainfall plays a vital role for agriculture in India. 68% of cultivated land to the total cultivated land of India is occupying by the rain fed agriculture which supports 60% of livestock population and 40% of human population (Meshram et al., 2017). The amount of soil moisture for crop production is totally determined by the amount of rainfall (Gupta et al., 2013). It is difficult to quantify the rainfall event as they vary over time which include several dimensions like the amount of rainfall, types of rainfall, rainfall duration and rainfall intensity (Lan et al. 2005). The dimensions are largely dependent on the availability of rainfall data of a particular area (Shamsudin et al. 2010).

Study Region

The Haora River Basin, situated in the northeastern Indian state of Tripura, is an essential hydrological and ecological area that plays a significant role in the region's environment and economy. It spans an area of approximately 457.92 square kilometers and lies within the Tropic of Cancer, particularly between latitudes 23°37'N and 23°53'N and longitudes 91°15'E and 91°37'E. This geographical positioning subjects the river basin to a tropical climate, which is characterized by relatively high temperatures and significant rainfall. The mean monthly temperatures in the summer months can range from a comfortable 19.50°C to a much warmer 30.70°C, indicating the seasonal variations that affect the local ecosystem and agricultural practices. The climatic conditions in the Haora River Basin are greatly influenced by the southwest monsoon, which arrives around June and lasts until the end of September. During this monsoon season, the region experiences intense rainfall, with total annual precipitation ranging from 1,619.30 mm to 2,985.10 mm. This period accounts for approximately 70% to 80% of the basin's yearly rainfall, creating a significant impact on both the hydrology and agriculture within the area. The heavy monsoon rains are crucial for replenishing water resources in the Haora River Basin, supporting a diverse range of flora and fauna while also sustaining agricultural activities. The seasonal rainfall also poses challenges, as excessive rainfall can lead to flooding, impacting livelihoods and infrastructure. The complex interaction of temperature, rainfall, and local geography defines the ecological character of the basin, making it a vital area for biodiversity. This region's climate not only shapes its natural landscapes but also affects the socio-economic activities of the communities dependent on its resources. Understanding these dynamics is essential for effective management and conservation efforts in the Haora River Basin.

Objectives

(1) To study examines the trends of daily rainfall and its associated factors in Haora River basin
(2) To analyse the variability of seasonal and annual rainfall over the decades of 10 years in the Haora River Basin.

Database and Methodology

A relatively long precipitation data series of Haora River Basin is selected for analysing rainfall variability. Daily rainfall data is gathered from India Meteorological Department, Agartala, Tripura for 10 years (2009-2018) and are used for statistical analysis. Statistical analysis for each year was calculated the extreme values of rainfall duration from 1 day to 26 consecutive days. Also used for a detailed analysis of annual and seasonal rainfall trends and periodicity along the basin. The rainfall variability calculated with statistical method, to analyse rainfall variability of annual and seasonal. The basic statistical analysis used in this study is measure of central tendencies (mean and mediation), measure the dispersion (standard deviation), and the degree of symmetry in the distribution (Skewness, SK), the degree to peak of data (Kurtosis/KT), z-score and coefficient of variation (CV).

Annual and seasonal rainfall patterns of the region were examined by processing the daily rainfall data. Rainfall variability at annual and seasonal bases was analysed by determining coefficient of variation (CV).It is computed as:

$$CV=\frac{\sigma}{\mu \times 100}$$

Where, σ is standard deviation and μ is the mean precipitation. Values of CV indicate lower, moderate, and higher variability, respectively (Habte et al., 2023).

Results and Discussion

The rainfall in the Haora River Basin is subject to a complex interplay of various environmental and atmospheric factors, such as atmospheric circulation patterns, monsoon winds, ocean currents, and the region's topography, as outlined by Athira et al. (2023). This intricate relationship leads to a significant variability in the amount and distribution of rainfall across different temporal scales, particularly between the years 2009 and 2018. Throughout this decade, the basin has experienced fluctuations in annual rainfall amounts, with each year exhibiting distinct characteristics in terms of precipitation levels. This variability reflects not only the differences in annual totals but also highlights the broader trends in rainfall patterns within the basin over time. The underlying causes of this rainfall variability are multifaceted and include essential hydrological processes such as changes in precipitation itself, rates of evaporation and transpiration, soil moisture content, and the levels of groundwater. These factors continuously interact, creating a dynamic system that influences the overall hydrological health of the Haora River Basin (Sehler et al., 2020). Understanding how these components interrelate is critical for managing water resources effectively in the region, as well as for predicting and adapting to future climatic changes. The impacts of such variability can have significant implications for agriculture, water supply, and ecosystem health within the basin, emphasizing the need for comprehensive studies and ongoing monitoring. In conclusion, the rainfall dynamics of the Haora River Basin reflect a delicate balance of natural forces and local environmental conditions, underscoring the importance of integrated water management strategies to cope with its variations.

Annual Variation of Rainfall

In the Haora River Basin, a detailed examination of the annual rainfall data reveals significant fluctuations across different years, illustrating the basin's complex hydrological behavior. The year 2017 stands out as the wettest year on record, with a staggering total rainfall of 2985.10 mm. This exceptional precipitation likely contributed to a more considerable impact on the region's ecosystems and human activities. In contrast, 2011 was marked by the least amount of rainfall, recording only 1619.30 mm and coinciding with the fewest rainy days observed in the study period, totaling just 72 days. During this period, various other rainfall totals were also documented, such as 1987.20 mm in 2009 and a substantial increase in 2018, when the rainfall reached 2058.46 mm. notably, 2017 also registered the most rainy days within the decade, with a total of 107 days, coupled with an impressive average rainfall intensity of 27.90 mm per day. Conversely, the year 2016 exhibited the lowest average intensity of rainfall, measured at 20.11 mm per day, indicating a drier condition. Statistically, the variability of rainfall was most pronounced in 2017, which recorded the highest standard deviation of 26.90 mm, showcasing greater fluctuations in daily rainfall amounts. This contrasts sharply with 2012, which exhibited the lowest standard deviation at 19.11 mm, indicating more stable rainfall patterns that year. Analyzing the temporal variation of seasonal rainfall from 2009 to 2018 further illustrates the dynamic nature of precipitation in the basin. The fluctuation in annual rainfall during this period increased considerably, with variations soaring from 149.98% to an even more dramatic 174.40%. The year 2018, in particular, demonstrated a high degree of rainfall variability, as evidenced by its coefficient of variation of 174.40%.

In contrast, 2015 recorded the lowest coefficient of variation at 136.41%, indicating a comparatively steadier rainfall pattern. The statistical analysis also reveals insights into the distribution characteristics of rainfall, specifically in terms of skewness and kurtosis. The year 2009 recorded the highest skewness at 5.35, accompanied by an exceptionally high kurtosis value of 41.71, suggesting a significant concentration of extreme rainfall amounts. Conversely, 2017's skewness dropped to 2.22, which corresponds with its relatively low kurtosis value of 4.87. This relationship highlights an intriguing dynamic where higher kurtosis values can correlate with elevated skewness and vice versa. The observed variability in annual rainfall quantities has substantial implications for hydrological processes within the

Haora River Basin. These fluctuations directly influence stream flow patterns and impact the spatio-temporal distribution of runoff, groundwater reserves, and soil moisture levels across the basin, as previously described by researchers such as Srivastava et al. (2015) and Islam et al. (2012). Furthermore, the pronounced variability in rainfall trends heightens the risk of extreme weather events, including droughts and floods, which have become increasingly frequent according to findings presented by Praveen et al. (2020). The consequences of excessive rainfall can lead to catastrophic situations, including water logging and flooding, posing significant challenges to infrastructure and communities within the region.

Seasonal Variation of Rainfall

Rainfall patterns in the Haora River Basin exhibit significant variability, both in terms of spatial distribution and temporal dynamics. This region experiences a distinct seasonal rainfall cycle, which can be broadly categorized into three primary phases: the Pre-Monsoon season spanning from March to May, the Monsoon season from June to September, and the Post-Monsoon period from October to December. During the Monsoon season, the basin is subjected to a higher frequency of extreme weather events, including cloudbursts that lead to intense and sudden rainfall. Statistical analysis reveals that high-intensity rainfall events are most prevalent during the Monsoon, with an average intensity recorded at 21.92 mm per day. This figure is accompanied by a relatively low standard deviation of 22.64 mm, suggesting a certain level of consistency in rainy days but with potential for abrupt weather changes (Table-1). Notably, the highest peaks in rainfall are typically documented in the months of June and July, indicating that these periods are critical for understanding the region's hydrological behavior. Conversely, the months of November and December have seen a decrease in total rainfall volumes, amounting to only 1820.20 mm, which poses concerns for agricultural practices during the post-monsoon period. The statistical analyses of rainfall during the Monsoon season yield a low skewness value of 3.31, which, alongside a kurtosis value of 16.06, indicate that rainfall amounts during this season, tend to cluster around a mean value with fewer outliers (Table-1). In contrast, the post-monsoon season demonstrates higher skewness and kurtosis values, suggesting greater variability and potential for unpredictable rainfall patterns. The predictable nature of the Monsoon rainfall is critical for agricultural planning and practices, particularly for crops with elevated water requirements, such as rainfed crops. However, the inherent variability in rainfall presents significant challenges for crop production throughout the region (as highlighted by Habte et al., 2021). Fluctuations in rainfall concentration not only diminish runoff volumes but also constrain overall agricultural production and productivity, significantly impacting farming activities within the basin (Kyei-Mensah et al., 2019; Sujariya et al., 2020). Moreover, the dynamic alterations in both the amount of rainfall and the frequency of rainy days during the Monsoon season perturb agricultural extension efforts and disturb the selection of crop varieties suitable for the region (Ayanlande et al., 2018). Central to these challenges is the overarching impact of climate change, which has emerged as a significant factor influencing rainfall variability in the Haora River Basin (Table-1). This climate phenomenon is evident in the declining prevalence of summer monsoonal rainfall, contrasted by an increasing share of precipitation during the Post-Monsoon and Pre-Monsoon seasons. This shift complicates agricultural strategies and requires adaptive measures to mitigate the adverse effects of changing climatic conditions on crop production.

Table-1: Seasonal Rainfall Pattern and Variability in Haora River Basin, Tripura

Seasons	Total Rainfall (mm)	Mean Rainfall (mm)	STD (mm)	CV (%)	No of Rainy Days	Rainfall Intensity (mm/day)	Skewness	Kurtosis
Pre-Monsoon	6088.50	18.56	26.00	140.09	232	26.24	3.48	19.92
Monsoon	12558.96	14.59	22.64	155.24	573	21.92	3.31	16.06
Post-Monsoon	1820.20	13.38	23.56	176.06	81	22.47	4.12	22.82

Source: Authors

Identification of Stormy Days

To effectively identify and analyze the rainstorms occurring within the Haora River basin, a statistical approach known as the z-score analysis has been employed. This method classifies stormy days into seven distinct categories, each based on the z-score values that range from below 0 to above 4.5. By categorizing these storms, researchers aim to gain a clearer understanding of rainfall patterns and intensities within the region. In the category of Extremely Low Intensity Storms, which are defined by a z-score below 0, a total rainfall amounting to 3974.86 mm has been recorded, accompanied by a notably high variation in rainfall, represented by a coefficient of variation (CV) of 98.48% (Fig. 1). This suggests that the rainfall amounts on these days can fluctuate significantly, indicating extreme unpredictability. In the Very Low Intensity Storms category, the total recorded rainfall was approximately 3625.2 mm, with an average daily rainfall of just 20.37 mm.

On the other hand, Low Intensity Storms, classified by z-scores ranging from 0.5 to 1.5, exhibited the highest total rainfall, which reached up to 5253.10 mm. This indicates that these storms deliver more substantial rainfall compared to the Extremely Low and Very Low categories. Interestingly, the data also reveal that High Intensity Storms exhibit a slight negative skewness of -0.05, while Extremely Low Intensity Storms show a positive skewness value of 1.01. These skewness values provide insights into the distribution of rainfall amounts, indicating that the majority of Extremely Low Intensity Storms are characterized by light rainfall. Focusing on a more recent ten-year period, specifically from 2009 to 2018, the analysis highlights significant variations in rainfall patterns. Within the Extremely Low Intensity Storms (z-score below 0), the coefficient of variation remains high at 98.48%, indicating unpredictable and inconsistent rainfall during these events. Conversely, Very High Intensity Storms, characterized by z-scores ranging from 3.5 to 4.5, display low rainfall variability with a coefficient of variation of just 7.31% (Table-2 and Fig. 1). Overall, during this decade-long span, the data indicates that there was a total of 894 days classified as rainy, with a cumulative rainfall total of 20,598.36 mm. When averaged, the intensity of rainfall across these days' amounts to approximately 23.04 mm per day. This comprehensive analysis underscores the complexity and variability of rainstorms in the Haora River basin, ultimately contributing valuable insights into hydrological patterns and potential impacts on the region's environment and water management strategies (Fig. 1).

Storm Duration

Storm duration plays a crucial role in the rainfall-runoff process, as highlighted by Shi et al. (2017). It is essential to understand how the duration of rainfall events influences the hydrological response of a given area. In this study, a total of 417 rainfall events were documented, emphasizing the relationship between rainfall depth and duration. A significant finding from the data is that shorter-duration rainfall events, particularly those lasting just one day, occurred with remarkable frequency (Table-2). In fact, one-day rainfall events accounted for 142 occurrences, which represents approximately 34.05% of all recorded events. This prevalence of one-day events underscores their importance in the overall rainfall pattern of

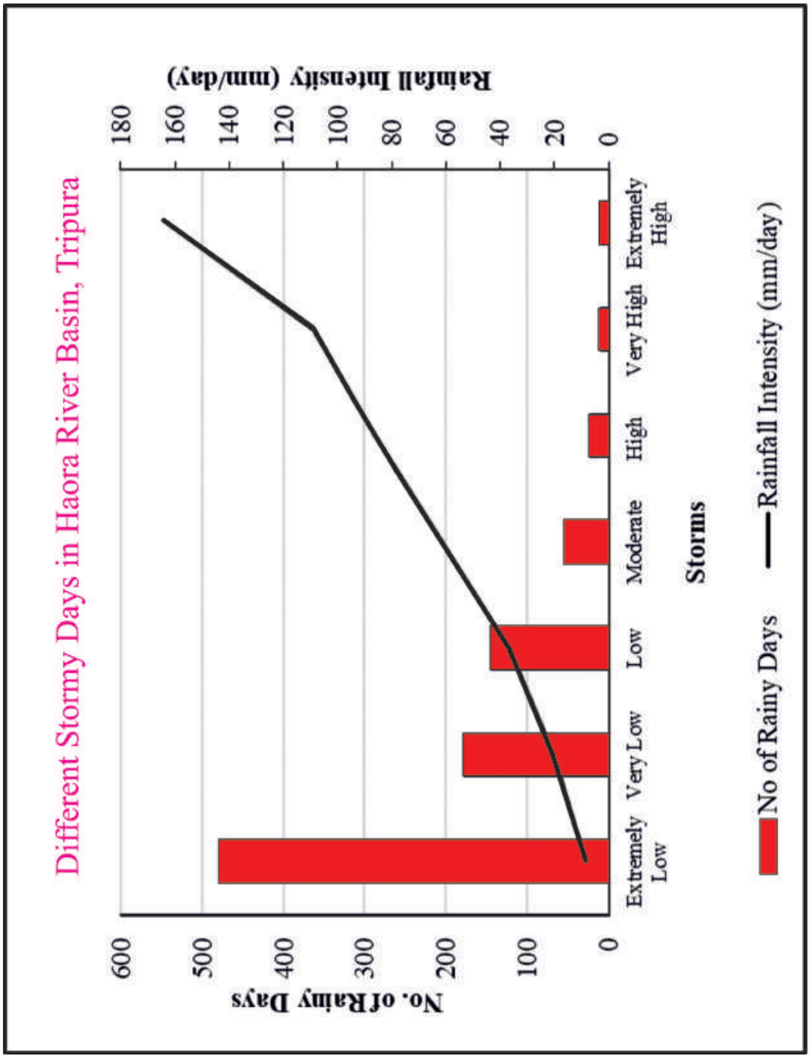
Different Stormy Days in Haora River Basin, Tripura
No. of Rainy Days
600
500
400
300
200
100
0
Rainfall Intensity (mm/day)
180
160
140
120
100
80
60
40
20
0
Extremely Low
Very Low
Low
Moderate
High
Very High
Extremely High
Storms
No of Rainy Days
Rainfall Intensity (mm/day)

Fig. 1

Table-2: Characteristics of Rainstorm Events in Haora River Basin, Tripura (2009-2018)

Storms	Z Value	Total Rainfall (mm)	Mean Rainfall (mm)	STD (mm)	CV (%)	No of Rainy Days	Rainfall Intensity (mm/day)	Skewness	Kurtosis
Extremely Low	Below 0	3974.86	4.27	4.20	98.48	478	8.32	1.01	-0.10
Very Low	0-0.5	3625.20	20.37	3.45	16.96	178	20.37	0.34	-1.13
Low	0.5-1.5	5253.10	36.48	6.47	17.75	144	36.48	0.47	-0.83
Moderate	1.5-2.5	3244.00	61.21	6.33	10.35	53	61.21	0.21	-1.27
High	2.5-3.5	1893.10	86.05	8.04	9.34	22	86.05	-0.05	-1.61
Very High	3.5-4.5	979.60	108.84	7.96	7.31	9	108.84	0.64	-1.25
Extremely High	Above 4.5	1628.50	162.85	42.21	25.92	10	162.85	0.86	-0.22

Source: Authors

the region. Conversely, long-duration rainfall events, particularly those extending from 13 days to 26 days, were relatively rare. These longer events only comprised about 1.20% of the total recorded events, indicating that they are significantly less common compared to their shorter counterparts. Furthermore, an observable trend is that as the duration of rainfall increases, the total number of recorded events tends to decline. This trend suggests that while short, intense rainfall events may play a larger role in driving runoff, longer-duration events may contribute differently to the hydrological cycle. In terms of the frequency of rainy days, the data reveals that the highest number of rainy days recorded was 118, corresponding to 3-day duration events. This duration of rain seems to provide an optimal balance, allowing for a substantial number of days within which precipitation occurs. On the other hand, longer-duration events, such as those lasting 13 days, exhibited a significantly lower frequency, with only 7 rainy days noted during this period. Additionally, these longer events were characterized by a markedly lower mean rainfall measurement, averaging only 8.91 mm (Fig. 2). The analysis of rainfall patterns reveals that the highest intensity of rainfall is typically associated with events lasting a duration of

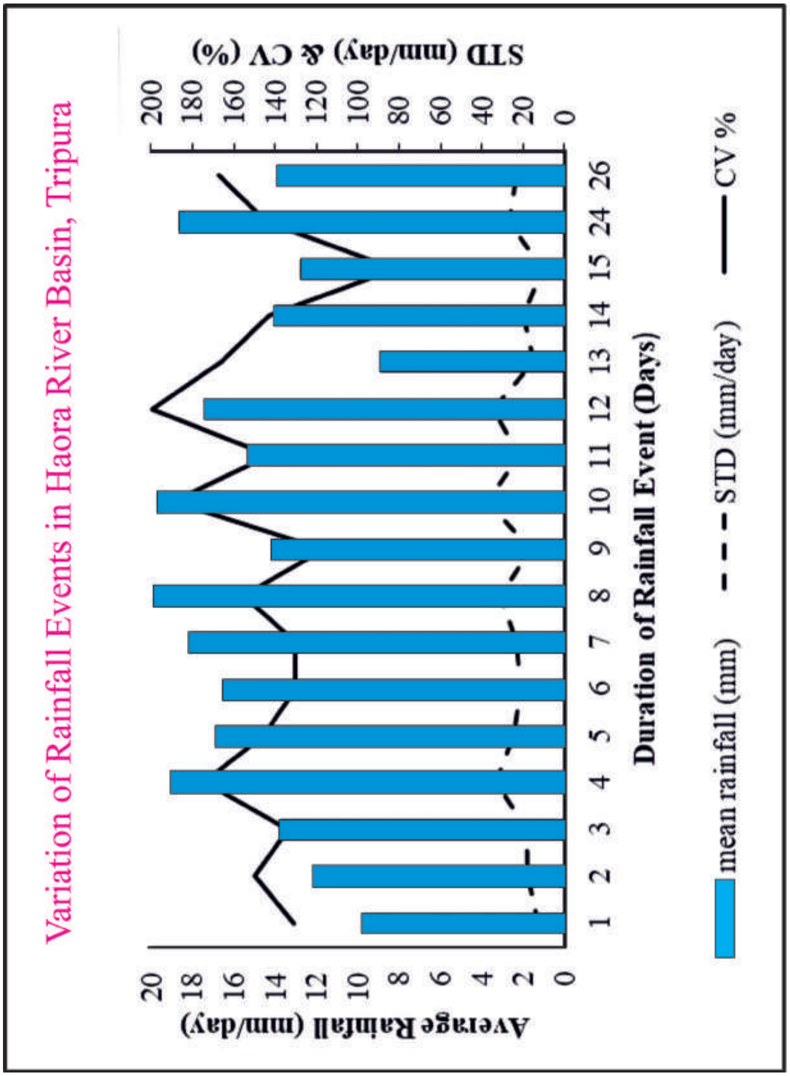
Variation of Rainfall Events in Haora River Basin, Tripura
Average Rainfall (mm/day)
STD (mm/day) & CV (%)
Duration of Rainfall Event (Days)
mean rainfall (mm)
STD (mm/day)
CV %

Fig. 2

10 days, where the recorded average rainfall intensity reaches an impressive 29.51 mm per day. Additionally, there are specific duration events lasting 13, 14, 15, 24, and 26 days, each characterized by a singular occurrence of a rainstorm. During these events, the rainfall intensity exhibits variability, fluctuating between 16.31 mm per day and 26.25 mm per day, indicating a range of precipitation levels that can impact the area differently. Moreover, the Haora River Basin, an important hydrological region, experiences its maximum rainfall during the monsoon season. This critical period typically spans from May to July, when the combination of weather patterns leads to heightened precipitation. Conversely, the month of December is noteworthy for being a time of minimal rainfall, with the region often receiving little to no precipitation at all. This seasonal contrast significantly influences the ecological and hydrological dynamics within the Haora River Basin and underscores the importance of monitoring rainfall patterns for effective water management strategies in the region.

Conclusion

The study provides a comprehensive examination of the variations in rainfall patterns within the Haora River Basin over a substantial timeframe of ten years, specifically from 2009 to 2018. Utilizing a range of statistical methods, the researchers meticulously analyzed the annual and seasonal rainfall data, uncovering a significant spectrum of variability that ranges from low to high throughout this designated period. One of the key findings of the research indicates that the variability in rainfall is particularly pronounced during extremely low-intensity storm events. In contrast, the data illustrates that extremely high-intensity storms elicit a relatively low degree of variability in rainfall measurements. This nuanced understanding of rainfall variability is crucial for water resource management and flood forecasting in the region. Additionally, the study highlights the distinct seasonal rainfall patterns experienced by the Haora River Basin. The rainfall cycle is categorized into three primary seasonal phases: the Pre-Monsoon period, which occurs from March to May; the Monsoon season, spanning June to September; and the Post-Monsoon phase, which lasts from October to December. Among these phases, monsoonal rainfall emerges as the most significant contributor to the overall precipitation within the basin, underscoring the importance of the monsoon season for local hydrology and ecology. In conclusion, this research not only sheds light on the temporal fluctuations in rainfall within the Haora River Basin but also emphasizes the critical role of seasonal dynamics in influencing the region's hydrological patterns. Understanding these variations is essential for developing effective water management strategies, mitigating the impacts of extreme weather events, and promoting sustainable agricultural practices in the area.

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AN ANALYTICAL COMPARISION OF SUGARCANE PRODUCTION IN NORTHERN AND SOUTHERN INDIA: A GEOGRAPHICAL OUTLOOK

Kunvar Chandra Verma, Dr. Pranay Kant Biswas and Sandesh Bandhu

Abstract

Sugarcane is an important crop, which is an important ingredient of economic landscape of India. It is main raw material for sugar industry, which play a major role in economy of India. If we talk about the distribution of area under sugarcane cultivation, production and yield of sugarcane in India, then there are a lot of variations in area under sugarcane cultivation, production and yield of sugarcane and in northern and southern states of India. Which are results of climate, soil structure, means of irrigation, level of mechanization, level of technological development, availability of electricity, labor and government policies. In the present study main emphasize on nature of cultivation, production, yield and productivity, variations in production of sugarcane in northern and southern states, factor affecting these variations in northern and southern India.

Introduction

As we know that India is an agrarian country, whose economy mainly depends upon agriculture directly or indirectly. Sugarcane is an important component of agricultural landscape of India having dietary and commercial applications. Cultivation of sugarcane is an important component of agriculture. Sugarcane is used as main raw material for sugar industry and used as important component for other allied industries and a major resource of molasses, which is used in many industries as raw-material. Sugarcane is an important commercial crop in India and is important raw material for the sugar industry (Shabana Anjum and Madhulika, 2018). India stands second after Brazil in production of sugarcane. Cultivation of sugarcane is done throughout the country. But their production, yield and harvesting

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varies greatly from one part of the country to another, which is the product of so many geographical factors, such as climatic condition, soil, means of irrigation, availability of labor force, availability of power resources, means of transportation, and nearness to the market centers and production centers and governmental policies. The contribution of sugarcane to the national GDP is 1.1% which is significant considering that the crop is grown only in 2.5% of the gross cropped area The contribution of sugarcane to the agricultural GDP has steadily increased from about 5% in 1990-91 to 10% in 2011-11 during the past two decades, the average annual growth of sugarcane agriculture sector was about 2.6 percent, as against the overall growthy of 3% in agricultural sector in the country (ICAR, 2015). More than 50 million farmers are dependent and large number of agricultural laborers are involved in sugarcane cultivation harvesting and ancillary activities constituting 7.5 percent of rural population and many workers are employed indirectly in processing (Ashutosh Kumar Ranjan et.al., 2020). Obtaining a maximum yield from the sugarcane crops improves those farmers economic condition (Powar et. al., 2020). Sugarcane growing countries of the world are located between the latitude of 36.7° north and 31.0° south of the equator ranging from tropical to subtropical zones (Sumit Shukla te.al., 2023). Plants of the sugarcane originally originated in New Guinea where it has been known for thousands of years (Daniels, J, and Roach, B.T. 1987).

Study Region

Study area selected for the present study is situated in northern as well as in southern part of the country. Jammu and Kashmir, Punjab, Haryana, Uttar Pradesh, Uttarakhand and Rajasthan are major states of Northern India. Total area of the northern India is 2389,300 sq. kilometer and population of this part is 912030836, in this way 72 percent area is covered by northern India and 75 percent population of the country lives in northern India. Indo-Gangetic plain, mighty Himalayas, the Thar Desert and central highlands are the main geographical features of northern India. This part of the country is most productive part from agricultural point of view. Andhra Pradesh, Karnataka, Kerala Maharashtra and Tamil Nadu are part of southern India south India is also termed as peninsular India; it is southern part of the peninsular Deccan. Total area of south India is 635780 sq. kilometer, and population of south India is 253051953, in this way south India covered 19.31 percent area and 20 percent population of India.

Objectives

(1) To study the comparative analysis of trends in sugarcane production in northern and southern part of India
(2) To examine the changes in sugarcane cultivation regions.

Database and Methodology

For the present study data about area under sugarcane, production and yield of sugarcane in states of India has been obtained from the official reports such as Co-operative sugar Vol. 53, no. 12, August 23 of agricultural department namely ministry of India. For the analysis of sugarcane cultivation in India trend analysis of data has been performed to understand the nature and variations in sugarcane cultivation. Suitable diagrams and tables also have been prepared to understand the phenomenon in more lucid and clear way.

Result and Discussion

Trends in Area under Sugarcane in Northern and Southern states India during 1990-2020

Table-1 shows the pattern of area under sugarcane cultivation in states on northern and southern India during the time period of 1990-2020. Data given in table no.1 shows that the area under cultivation varies from states to state and from year to year both in northern and southern states. It is clear from the table that area under sugarcane in Uttar Pradesh, Punjab and Haryana tends to fluctuate in regular manner, while in other states of northern India show declining trends. Area under sugarcane was recorded as 1856000 hectares in 1990, which goes down to 1839000 hectares in 1995, it again increased to 2011000 hectares in 2000, it again goes down to 1955000 hectares in 2005, which again increased to 1977000 hectares in 2010, 2141000 hectares in 2015 and 2208000 hectares in 2020. In state of Punjab area under sugarcane was recorded as101000 hectares in 1990, which decreased to 83000 hectares in 1995, which increased to 108000 hectares in 2000, which again decreased to 86000 hectares in 2005, 60000 hectares in 2010, which again increased to 94000 hectares in 2015, which again comes down to 91000 hectares in 2020. In state of Haryana, area under sugarcane was recorded as 148000 hectares in 1990, which decreased to 120000 hectares in 1995, 97000 hectares in 2000, area under sugarcane increased to 130000 hectares in 2005, which again decreased to 74000 hectares in 2010, which increased to 93000 hectares in 2015 and 96000 hectares in 2020 (Fig. 1 and Table-1).

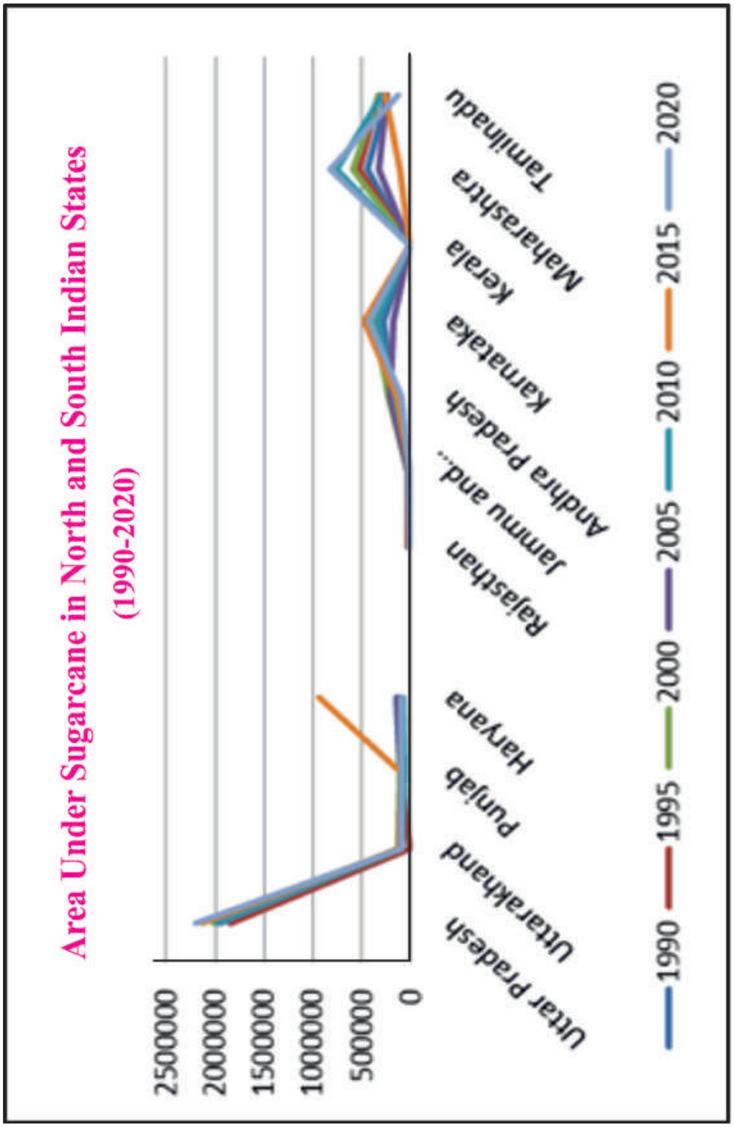
Area Under Sugarcane in North and South Indian States
(1990-2020)
2500000
2000000
1500000
1000000
500000
0
Uttar Pradesh
Uttarakhand
Punjab
Haryana
Rajasthan
Jammu and...
Andhra Pradesh
Karnataka
Kerala
Maharashtra
Tamilnadu
1990
1995
2000
2005
2010
2015
2020

Fig. 1

Table-1: Area under Sugarcane in North and South Indian States (1990-2020)

Year/States	1990	1995	2000	2005	2010	2015	2020
Area under Sugarcane in North Indian States (In Hectare)							
Uttar Pradesh	1856000	1839000	2011000	1955000	1977000	2141000	2208000
Uttarakhand	0	0	122000	107000	96000	102000	92000
Punjab	101000	83000	108000	86000	60000	94000	91000
Haryana	148000	120000	97000	130000	74000	93000	96000
Rajasthan	23000	22000	14000	6000	5000	6000	4000
Jammu and Kashmir	17000	18000	16500	16000	11000	10000	13000
Area under Sugarcane in South Indian States (In Hectare)							
Andhra Pradesh	182000	209000	231000	210000	158000	139000	86000
Karnataka	272000	345000	373000	178000	337000	480000	429000
Kerala	8000	6000	3000	7000	3000	1000	1000
Maharashtra	444000	518000	590000	324000	756000	103000	822000
Tamil Nadu	233000	327000	316000	232000	293000	263000	131000

Sources: Co-operative Sugar Vol.53, No. 12 August 2022

In other states such as Uttarakhand, Rajasthan, and Jammu and Kashmir area under sugarcane cultivation shows regular declining trends in regular manner during the time period of 1990 to 2020. In Uttarakhand area under sugarcane was recorded in 2000, as 122000 hectares, which came down to 107000 hectares in 2005, 96000 hectares in 2010, 102000 hectares in 2015 and 92000 hectares in 2020. In case of Rajasthan area under sugarcane was recorded as 23000 hectares in 1990, which decreased to 22000 hectares in 1995, 14000 hectares in 2000, 6000 hectares in 2005, 5000 hectares in 2010, which increased to 6000 hectares in 2015 which again decreased to 4000 hectares in 2020. If we talk about the trends in area under sugarcane in Jammu and Kashmir, then we find out that the area under sugarcane was recorded as 17000 hectares in 1990, which increased to 18000 hectares in 1995, which decreased to 16500 hectares in 2000, 16000 hectares in 2005, 11000 hectares in 2010, 10000 hectares in 2015, which increased to 13000 hectares. If we talk about the trends in area under sugarcane in south Indian states, than we find out that the area under sugarcane tends to increase in states of Karnataka and

Maharashtra, while in state of Tamil Nadu it fluctuate regularly from one year to another, while in states of Andhra Pradesh and Kerala it tends to decrease regularly. In Andhra Pradesh, area under sugarcane was recorded as 182000 hectares in 1990, which increased to 209000 hectares in 1995, 231000 hectares in 2000, which increased to 210000 hectares in 2005, which again increased to 158000 hectares in 2010, 139000 hectares in 2015 and 86000 hectares in 2020. In state of Kerala area under sugarcane was recorded as 8000 hectares in 1990, which deceased to 6000 hectares in 1995, 3000 hectares in 2000, which increased to 7000 hectares in 2005, which again increased to 3000 hectares in 2010, 1000 hectares in 2015 and was again recorded as 1000 in 2020. In state of Tamil Nadu area under sugarcane was recorded as 233000 hectares in 1990, which increased to 327000 hectares in 1995, which decreased to 316000 hectares in 2000, 232000 hectares in 2005, which again increased to 293000 hectares in 2010, which again decreased to 263000 hectares in 2015 and 131000 hectares in 2020. In state of Karnataka area under sugarcane was recorded as 272000 hectares in 1990, which increased to 345000 hectares in 1995, 373000 hectares in 2000, which decreased to 178000 hectares in 2005, which again increased to 337000 hectares in 2010, 480000 hectares in 2015 and decreased to 429000 hectares in 2020. In state of Maharashtra area under sugarcane was recorded as 444000 hectares in 1990, which increased to 518000 hectares in 1995, 590000 hectares in 2000, which decreased to 324000 hectares in 2005, which again increased to 756000 hectares in 2010, 103000 hectares in 2015 and it decreased to 822000 hectares in 2020. In south India, Maharashtra has recorded maximum area under sugarcane.

Trends in Production of Sugarcane in Northern and Southern States of India during 1990-2020

Table-2 and Fig. 2 shows the trends in production of sugarcane in northern or south Indian states during the time period of 1990-2020. According to the table and graph mentioned above the production of sugarcane in north Indian states shows variations from one year to another and from one state to another state during the time period of 1990-2020. States of Uttar Pradesh and Uttarakhand have shown increasing trends in production of sugarcane, while the states of Punjab, Haryana, Jammu and Kashmir and Rajasthan have shown the fluctuating trends in production of sugarcane. States of Uttar Pradesh and Uttarakhand have shown maximum increase and the states of Punjab and Haryana have shown minimum increase in production of sugarcane in during the time period of 1990-2020 (Fig. 2). If we talk about the trends in the production of sugarcane in South Indian states, then all the

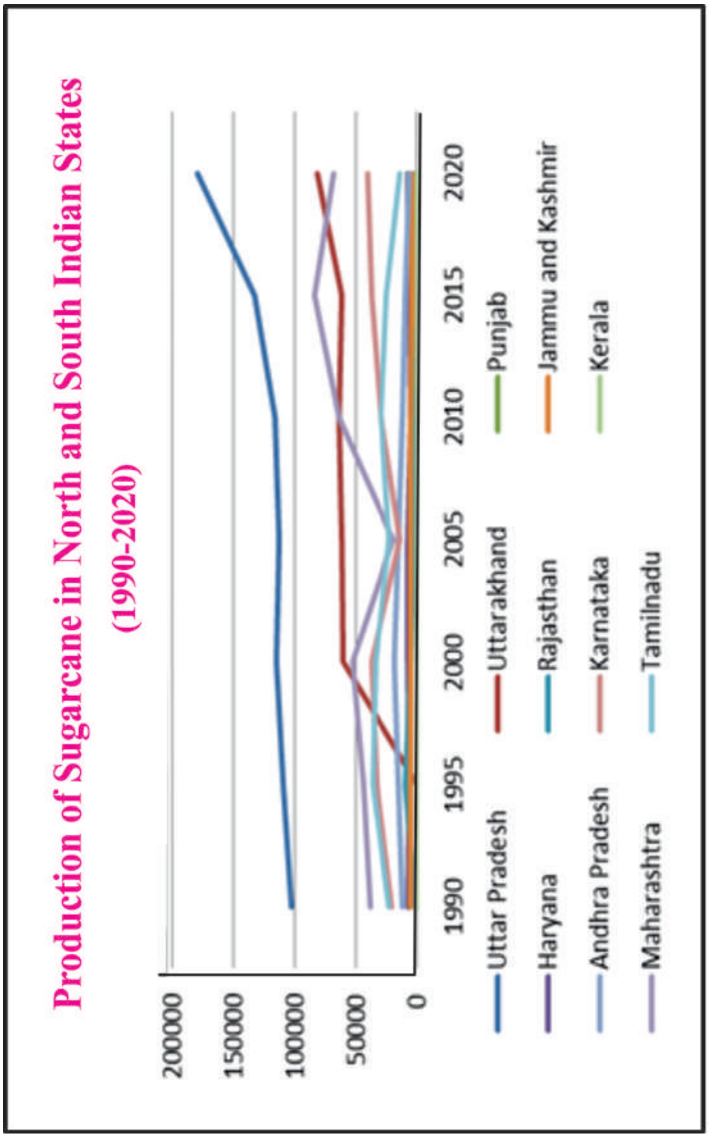
Production of Sugarcane in North and South Indian States
(1990-2020)
200000
150000
100000
50000
0
1990
1995
2000
2005
2010
2015
2020
Uttar Pradesh
Uttarakhand
Punjab
Haryana
Rajasthan
Jammu and Kashmir
Andhra Pradesh
Karnataka
Kerala
Maharashtra
Tamilnadu

Fig. 2

states of south India except Karnataka have shown fluctuating trends in production of sugarcane from year to year. The state of Karnataka has shown regular increase in production of sugarcane during 1990-2020. In the state of Uttar Pradesh production of sugarcane was recorded as 103562 tonnes in 1990, which increased to 110239 tonnes in 19995, 115419 tonnes in 2000, which decreased to 112754 tonnes in 2005, and increased again to 117140 tonnes in 2010, 133061 tonnes in 2015 and 179539 tonnes in 2020. In the state of Uttarakhand production of sugarcane was recorded as 60840 tonnes in 2000, which increased to 61890 tonnes in 2005, 63949 tonnes in 2010, which decreased to 61723 tonnes in 2015, which again increased to 82349 tonnes in 2020. In both of the state's maximum increase in production of sugarcane was recorded in the year of 2020. In the state of Punjab production of sugarcane was observed as 6000 tonnes in 1990, which came down to 5160 tonnes in 1995, which increased to 6770 tonnes in 2000, which decreased again to 5170 tonnes in 2005 and 3700 tonnes in 2010, which increased again to 7039 tonnes in 2015, and 7855 tonnes in 2020. In case of production of sugarcane in the state of Haryana, it was recorded as 7800 tonnes in 1990, which decreased to 7010 tonnes in 1995, it again increased to 7640 tonnes 2000, 8060 tonnes in 2005, in 2010 it again decreased to 5335 tonnes, but in 2015 production of sugarcane again increased to 7169 tonnes in 2015 and 7855 tonnes in 2020. Production of sugarcane in the state of Rajasthan was recorded as 1203 tonnes in 1990, which increased to 9870 tonnes in 1995, it again decreased to 5610 tonnes in 2000, which decreased to 2770 tonnes in 2005, production of sugarcane in the state of Rajasthan increased to 3440 tonnes in 2010, and 3630 tonnes in 2015, which decreased again to 3260 tonnes in 2020. If we talk about the production of sugarcane in the state of Jammu and Kashmir, it was recorded as 5900 tonnes in 1995, which decreased to 5450 tonnes in 1995, 5400 tonnes in 2000 and 5300 tonnes in 2005, it again increased to 5500 tonnes in 2010, which decreased again to 4890 tonnes in 2015 and 4560 tonnes in 2020.

If we talk about the production of sugarcane in south Indian states, than we find out that production of sugarcane in most of the south Indian states tend to fluctuate from one year to another year. In Andhra Pradesh production of sugarcane was recorded as 12667 tonnes in 1990, which increased to 16046 tonnes in 1995, 18508 tonnes in 2000. It decreased to 15739 tonnes in 2005, 11708 tonnes in 2010, 9987 tonnes in 2015 and 6724 tonnes in 2020. In Karnataka production of sugarcane was recorded as 20964 tonnes in 1990, which increased to 33093 tonnes in 1995, and 37567 tonnes in 2000. Production of sugarcane in Karnataka state decreased to 14276 tonnes in 2005, which increased again to 30443 tonnes in 2010, 37834 tonnes in 2015 and 41088 tonnes in 2020, In case of Kerala, production of sugarcane tends to fluctuate in regular manner from one year to another. Production of sugarcane was recorded as 443 tonnes in 1990, which increased to 478 tonnes in 1995, which decreased to 276 tonnes in 2000, it increased again to 283 tonnes in 2005, which again decreased to 131 tonnes in 2010, which increased to 149 tonnes in 2015 and again deceased to 121 tonnes in 2020. If we talk about the production of sugarcane in Maharashtra state, then it has been observed that production of sugarcane in Maharashtra tend to increase in regular manner. Production of sugarcane was recorded as 38416 tonnes in 1990, which increased to 44260 tonnes in 1995, and 53143 tonnes in 2000; production of sugarcane shows a decreasing trend in 2005, which was 20475 tonnes. Production of sugarcane again increased to 64159 tonnes in 2010, which increased to 84699 tonnes, which again decreased to 69312 tonnes in 2020. Production of sugarcane shows a fluctuating trend from one year to another.

Table-2: Production of Sugarcane in North Indian States during 1990-2020

Year/States	1990	1995	2000	2005	2010	2015	2020
Production of Sugarcane in North Indian States							
Uttar Pradesh	103562	110239	115419	112754	117140	133061	179539
Uttarakhand	0	0	60840	61890	63949	61723	82349
Punjab	6000	5160	6770	5170	3700	7039	7855
Haryana	7800	7010	7640	8060	5335	7169	7567
Rajasthan	1203	9870	5610	2770	3440	3630	3260
Jammu and Kashmir	5900	5450	5400	5300	5500	4890	4560
Production of Sugarcane in South Indian States							
Andhra Pradesh	12667	16046	18508	15739	11708	9987	6724
Karnataka	20964	33093	37567	14276	30443	37834	41088
Kerala	443	478	276	283	131	149	121
Maharashtra	38416	44260	53143	20475	64159	84699	69312
Tamil Nadu	23480	36456	34285	23396	29746	25494	14119

Sources: Co-operative Sugar Vol.53, No. 12 August 2022

Production of sugarcane was recorded as 23480 tonnes in 1990, which increased to 36456 tonnes in 1995, which decreased to 34285 tonnes in 2000, which decreased to 23396 in 2005, it increased to 29746 tonnes in 2010, which decreased to 25494 tonnes in 2015, which decreased again to 14119 tonnes in 2020.

Factor Affecting to the Cultivation of Sugarcane

Cultivation of sugarcane affected by various factors, such as soil characteristics, climate, irrigation facilities, application of high yielding varieties (HYV) of seeds, mechanization of agriculture, means of transportation and government policies. These factors can be discussed as below;

(a) Soil Characteristics

Soil characteristics such as soil structure, productivity of soil greatly affect the cultivation and production of sugarcane. For example, soil of Uttarakhand, Uttar Pradesh, Punjab and Haryana has been developed by erosion, transportation and deposition work of rivers, predominately flowing in these states, such as Ganga, Yamuna, Sutlej, Beas, Ravi, Jhelum etc. developed the great north Indian plains, which are more productive and are backbone of agricultural scenario of north India. Similarly soil of Deccan is developed due to volcanic activities, due to which black color soils of Deccan is black, and black soil is famous for its moisture retention capacity due to which it maintains and preserve the water for longer duration, due to which production and per hectare yield is high in south India mainly in Maharashtra. Soil of Jammu and Kashmir is mountainous soil, which has low water retention capacity and low productivity due to lack of chemical and mineral ingredients, due to which productivity and per hectare yield of sugarcane in Jammu and Kashmir is low.

(b) Climatic Characteristics

Climatic characteristics of any region greatly affect the productivity and per hectare yield of sugarcane. Sugarcane is mainly a tropical crop, so tropical and sub-tropical type of climate is best suited for this crop, that's why sugarcane producing states of India mainly concentrated in tropical and sub-tropical areas. Humid, moist sub-humid, dry sub-humid to cold arid, semi-arid and arid type of climate having temperature ranges from 21^{0}C to 32^{0}C and rainfall ranges between 180- 3640 mm is most suitable for sugarcane. As sugarcane is mainly a tropical crop, so tropical climatic conditions of south Indian states of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala and Maharashtra favor the cultivation, production and yield of sugarcane, that's why the highest production and per hectare yield of sugarcane is mostly found in tropical areas of Andhra Pradesh, Karnataka, Kerala, Maharashtra and Tamil Nadu. Sugarcane s also cultivated in Uttar Pradesh, Uttarakhand, Punjab, Haryana, Rajasthan and Jammu and Kashmir, which are located in sub-tropical regions, dominated by sub-tropical type of climate, which is characterized by the extreme hot climate in the months of April to June, rainy season due to existence of south-west monsoon in the months of July to October, extreme cold climate in the months of December to January. Cane yield in sub-tropical region is lower due to short growing season, high temperature variations, moisture stress, pest, diseases, floods, water logging and poor rations.

(c) Irrigation Facilities

Plant of sugarcane required water ranges from 2000 mm to 3000 in tropical areas and 1400 mm to 1800 mm in sub-tropical areas. Water required during the various stages of sugarcane cultivation such as during period of germination, during the period of tillage, during the time of growth phase, during the time of maturity, planting and harvesting for good production and higher yield. So the production and per hectare yield is high in states of Karnataka, Kerala, Maharashtra, Tamil Nadu, Uttar Pradesh and Uttarakhand as irrigation facilities are well developed and rainfall is in sufficient quantity, on the other hand production and yield of sugarcane is low in Rajasthan and Jammu and Kashmir due to lack of irrigation facilities.

(d) Application of High Yielding Varieties (HYV) of Seeds

Good quality of seeds is important for cultivation of sugarcane. Application of high yielding varieties (HYV) and application of fertilizers helps in higher production and highest yield of sugarcane.

(e) Mechanization of Agriculture

For higher production and higher per hectare mechanization of agriculture and application of new means of agriculture helps greatly for higher production and higher per hectare yield, which reduce the per capita expenditure and helps to increase the output and income of the farmers.

(f) Means of Transportation

Development of means of transportation from the area of production to the areas of consumption and market also affect the cultivation of sugarcane as transportation cost of sugarcane put extra burden on farmers, and as sugarcane is perishable product so it is essential to send it to the sugar mills in time as delay in it will affect the output of the sugarcane.

Conclusion

It can be concluded that:

(1) Area under sugarcane in Uttar Pradesh, Karnataka and Maharashtra increasing regularly, on the other states, it is either fluctuating in decreasing in regular manner.
(2) Area under sugarcane was recorded minimum in Rajasthan in north India and in Kerala in south India.
(3) Maximum increase in area under sugarcane was recorded in Uttar Pradesh in north India and in Maharashtra in south India.
(4) Maximum increase in production of sugarcane was observed in the states of Uttar Pradesh and Uttarakhand on the other hand the states of Punjab and Haryana have shown minimum increase in production of sugarcane in during the time period of 1990-2020 in north India.
(5) In north India States of Uttar Pradesh and Uttarakhand have shown increase in production of sugarcane, while the production of sugarcane fluctuates in the states of Punjab, Haryana, Jammu and Kashmir and Rajasthan.
(6) In most of the south Indian states production of sugarcane shows fluctuation from one year to another year.
(7) Uttar Pradesh in north India and Maharashtra in south India have shown maximum increase in production of sugarcane, while Rajasthan in north India and Kerala in south India shown minimum production of sugarcane.
(8) Yield of sugarcane in northern Indian states shown increasing trends except the state of Jammu and Kashmir, where it decreasing in regular manner, on the other hand Yield of sugarcane in south Indian states shows fluctuating trends in yield of sugarcane during the time period of 1990-2020.
(9) Yield of sugarcane was recorded maximum in Kerala and Tamil Nadu.

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SPATIAL DISPARITIES IN THE LEVEL OF AGRICULTURAL DEVELOPMENT IN MANIPUR

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Abstract

Agricultural development is a multi-dimensional process. Various agricultural scientists, social scientists, economists and geographers are conceiving it in varieties of ways. The present paper attempts to study the availability of variables/ indicators, and to analyse the spatial disparities in the level of agricultural development in Manipur. The study is based on district- wise secondary data for the year 2003, 2011, 2017, 2018-19, 2019-20 and 2021 which is used to assess the level of agricultural development on the basis of calculating 'Z-Scores' and Composite Standard Score (CSS) techniques. 16 variables/indicators have been selected for the present study. After calculating Z-Scores of all 16 selected variables of agricultural development, and then, computing 'Composite Standard Scores'. All districts of the state have been classified into three categories viz., High (0.21 – 0.51), Medium (-0.32 – 0.20) and Low (-0.65 – -0.33) on the basis of composite standard scores. It therefore, shows that only Thoubal district accounted for high category of agricultural development, while Imphal East, Imphal -West, Bishnupur, Senapati are recorded medium category whereas Ukhrul, Chandel, Churachandpur and Tamenglong districts are observed low level of agricultural development. It is concluded that the topography and modern– agricultural packages, in spite of favourable agro-ecological conditions, play a significant role for the level of agricultural development in the state.

Introduction

The concept of agricultural development is wide and multi-disciplinary process. Agricultural Scientists, Social Scientists, Economists and Geographers are conceiving it in variety of ways. Since, agricultural development has variety of components of entire system of agricultural production, how those components are

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to be assessed and combined together. Therefore, the dimensions of measurement of agricultural development are important to study. Various quantitative as well as qualitative techniques have been adopted to determine the level of agricultural development. In order to reviewing the regional approach of agricultural development, it can be said that there are various studies on the regional disparities occurring in the rate of growth and productivity of agriculture in the context of agricultural development (Tiwari and Singh 1985, Shrivastava 1983, Singh 1994 and Chand and Chandra 1994, Gupta 1982) emphasises three dimensions of agricultural development i.e., (i) Productivity (ii) Technological progress and (iii) Institutional changes. Dubey (1992) also assessed the level of agricultural development on the basis of agricultural infrastructures, agricultural conditions and productivity. Krishnan (1984) gave a comprehensive concept of agricultural development by using productivity, crop-diversification and commercialisation for land use efficiency. Banerjee (1996) emphasised on its planning criteria and expresses that the carrying capacity of land is the main factor controlling the agricultural development.

Since agricultural productivity and growth are two main components of development of agriculture activities, agricultural productivity may give us more realistic pattern for development Geographers attempted it by preparing the composite index of agricultural productivity, and considering crop-area and crop-yield as its main attributes. (Shafi 1960, 1983, Giri et.al. 1966, Bhatia 1967 and Dayal 1984). The overall level of development of agricultural activities has been measured by aggregating into a single index of various indicators of agricultural production system and development of agricultural activities. (Jasim 2018, Dhakal 2017, Harish and Rayamane 2019, Banerjee 1996, Priya and Arul 2019 and Singh 2012, Abdollahzadeh and Kalantari et.al. 2012). Banerjee (1996) advocated quantitative methods to determine the agricultural development adopting relative indices for the four indicators i.e., (i) Land efficiency (ii) Agricultural mechanisation (iii) Fertilizer consumption and (iv) Carrying capacity of land. Shrivastava (1983) assigned different weights in indicators by using the method of standardised composite index by taking 7 indicators; (i) Percentage of consumer utilised power for irrigation (ii) Number of villages electrified (iii) Percentage under irrigated area to GCA (iv) Gross agricultural output (v) Consumption of fertilizers (vi) Percentage of agricultural advance to total deposits and (vii) Percentage of HYV seeds to total area.

Study Region

Manipur, a small landlock state, is located on the Eastern Himalayas (Purvanchal Himalaya), bordering Myanmar. Manipur is one of the smallest states of India having a geographical area of 22,327 sq.km with total population of 2.86 million as per census 2011. The state extends between 23049'45'' N to 25042'1''N latitudes and between 92058'23''E to 94043'35''E longitudes. The state is practically excellent natural beauty and rich cultural heritage with diverse socio-cultural characteristics. The state comprises 9 districts as per 2011 census, namely Senapati, Tamenglong, Churachandpur, Chandel and Ukhrul in hilly and mountain tracts, and Imphal East, Imphal West, Bishnupur and Thoubal districts exhibited in the valley (called Imphal valley) portions occupying one-tenth of the total geographical area of the state surrounded by hills and mountains in all sides. Now, there are 16 districts in Manipur. However, former 9 districts have been considered as study area because the new 7 districts are bifurcated from the former 9 districts and no separate data is available for the said new 7 districts. The Imphal valley is called "Rice Bowl of Manipur" because of its favourable geo-ecological conditions for the cultivation of Rice-crop in the agricultural practices, and accounts for more than 92 percent of total GCA under rice-crops. The entire economy of the state, therefore is based on rice-crop cultivation. Even though with the increasing trend of urbanisation and change in the landuse pattern of the Imphal valley, it still continues to be the Rice-Bowl of Manipur due to its favourable geo-ecological conditions.

Objectives

(1) To study the availability of indicators of the agricultural development in the state on the basis of selected district-wise variables.
(2) To analyse the regional disparities in the level of agricultural development of Manipur based on Z-Scores and Composite Standard Score techniques.

Database and Methodology

To validate the facts, 16 variables/indicators have been chosen district-wise from secondary data spanning the years 2003, 2011, 2017, 2018-19, 2019-20, and 2021 (Table-1). These indicators encompass various forms, including ratios, numbers, and percentages. Accordingly, each indicator utilized in computing agricultural development must undergo normalisation (Das et al., 2016). While numerous normalisation techniques exist, the five most commonly utilized methods are Ranking, Distance to Target, Z-score Standardisation, Min-max, and Proportionate Normalisation (Talukder et al., 2017). For this study, the Z-score normalisation method is adopted to standardise the indicators, and the agricultural development is evaluated using the composite index method. The Z-Score method is a statistical technique used to combine multiple variables into a single index score, one of the methods commonly adopted by the researchers, it basically tells us how many standard deviations a number is above or below the mean. It standardises and compares data points from different distributions. Z-score normalization is calculated by subtracting the mean from an indicator value and then dividing by its standard deviation (Table-1). If the standard deviation is calculated for a set of variables with a mean of 0 and then all values are divided by the standard deviation, the resulting set of values will have a standard deviation of 1 (Salzman, J. 2003). After performing normalization, the data have a common scale with a 0 mean and a standard deviation of 1. Since all Z-score distributions have the same mean and standard deviation, individual scores from different distributions can be directly compared. The advantage of this technique is that it provides no distortion from the mean, adjusting for different scales and variance. The output is dimensionless, and the relative differences are maintained due to the application of a linear transformation (Mei, Et al. 2007). Z-score is preferred when extreme values exist in the dataset (Nardo, Et al. 2005). Although the technique does not fully adjust for outliers, the minimum and maximum values are not as influential as in other techniques such as distance to target. When extreme values are present in the original data, Z-score normalisation takes these extreme values into account in a manner that does not distort their impacts on a composite indicator. In this way, an outlier, such as exceptional performance, is recognised and not ignored (Salzman, J. 2003). Z-Score is computed by using the formula, as:

$$Zi=\frac{(Xi\text{-}X)}{SD}$$

Where, Zi is the standard Z-Score, Xi is original values of the variables, x is the mean of X variables and SD is the standard deviation of X variables. Higher value of Z-Score indicates higher level of development. The Z-Scores of all the variables been aggregated district-wise to get the Composite Standard Scores (CSS) for each and every district of the state and is calculated by using the formula, as:

$$CSS=\frac{\sum(Zij)}{N}$$

Where, CSS is the Composite Standard Scores, Zij indicates the sum of Z-Scores of variables/indicators i of j districts and N is the number of selected variables. On the basis of Composite Standard Scores (CSS), all districts are classified into three categories i.e., High, Medium and Low level of agricultural development.

Table-1: Selected Variables Computing the Level of Agricultural Development

Variables	Indicators
X_1	Percentage of Agricultural Workforce
X_2	Percentage of Rural Population.
X_3	Percentage of Area under HYV and Improved seeds to total GCA
X_4	Percentage of GCA to Total Geographical Area
X_5	Percentage of NSA to Total GCA.
X_6	Percentage of Irrigated area to GCA
X_7	Use of Chemical Fertilizer (Kg/ha. Of GCA)
X_8	Percentage of Area under Rice to total GCA.
X_9	Agricultural Productivity of Rice (qu./ha)
X_{10}	Cropping Intensity (GCA/VSA×100)
X_{11}	Road Length per 1000 persons.
X_{12}	No. of Commercial Banks.
X_{13}	No. of Power Tillers/Tractors.
X_{14}	No. of Non-Industrial Co-operative Societies.
X_{15}	Percentage of Rural Electrification.
X_{16}	Literacy Rate.

Result and Discussion

Available Indicators for the Level of Agricultural Development in State

Percentage of Agricultural Workforce refers to the percentage of combine population of Main Cultivator and Main Agricultural Labour to the total Main Worker population. Human workforce in agriculture especially for rice cultivation in combination with modern infrastructure enhances crop production in the developing countries (Singh & Singh, 2021). It has been witnessed that human element has played a major role in the development of agriculture in the states like Punjab, Haryana and western Uttar Pradesh. Examining the intensity of agricultural work force in the state will prove beneficial since workforce is a factor for getting higher productivity especially in rice-crop, which is the most important crop in Manipur. The percentage of agricultural workforce population to the total population is recorded very low in the state with 17.94 percent (2011 Census). High value of Z-Score of the percentage of agricultural workforce is found in the district of Senapati (1.25) and Tamenglong (0.99) districts. The low level of score is accounted in the valley districts like Imphal West (-1.56), Imphal East (-1.35), Bishnupur (-0.66) and Thoubal (-0.10), districts (Table-2). Because of less application of modern agricultural inputs HYV & Improved Seeds, use of chemical fertilizers, percentage of irrigated land to total GCA in the state, the agricultural productivity of the state is very low. It shows a poor performance of agricultural development in the state. Area under consumption of HYV & improved to total GCA is recorded high level in the Thoubal district with (1.70) of Z-Scored and followed by Chandel district (0.27) (Fig. 1). Percentage share of irrigated land to GCA plays a significant role in the agricultural processes as well as for the successful farming operation. Population pressure on land demanding more production has led to the modification of traditional land use and making the introduction of irrigation a requirement. Although the entire receives a good amount of annual rainfall 1627.1 mm, it compensates the deficiency of rainfall such that crops would not be deprived of water. Hence, irrigation is no more a choice but a necessity for accelerated but sustained agricultural development (Abebe. 2015). High level of irrigated area is observed in Thoubal and Bishnupur districts with (1.01) and (0.54) Z-Scores respectively. The presence of most numbers of waterbodies i.e, lakes and a number of rivers and small streams provides good irrigation potential for the district.

Important irrigation works taken up in the district like the Thoubal Multipurpose Project also serves important source of irrigation for the vast paddy fields. Gross Cultivated Area (GCA) and Net Sown Area (NSA) are also important indicators for the development of agricultural activities. Table-2 reveals that the highest level of GCA is recorded in Imphal West district with 84.84 percent and followed by Thoubal district with 79.03 percent to the total geographical area of the districts (Fig. 1). Net Sown Area is the total area sown in a year. Higher percentage share of NSA to the

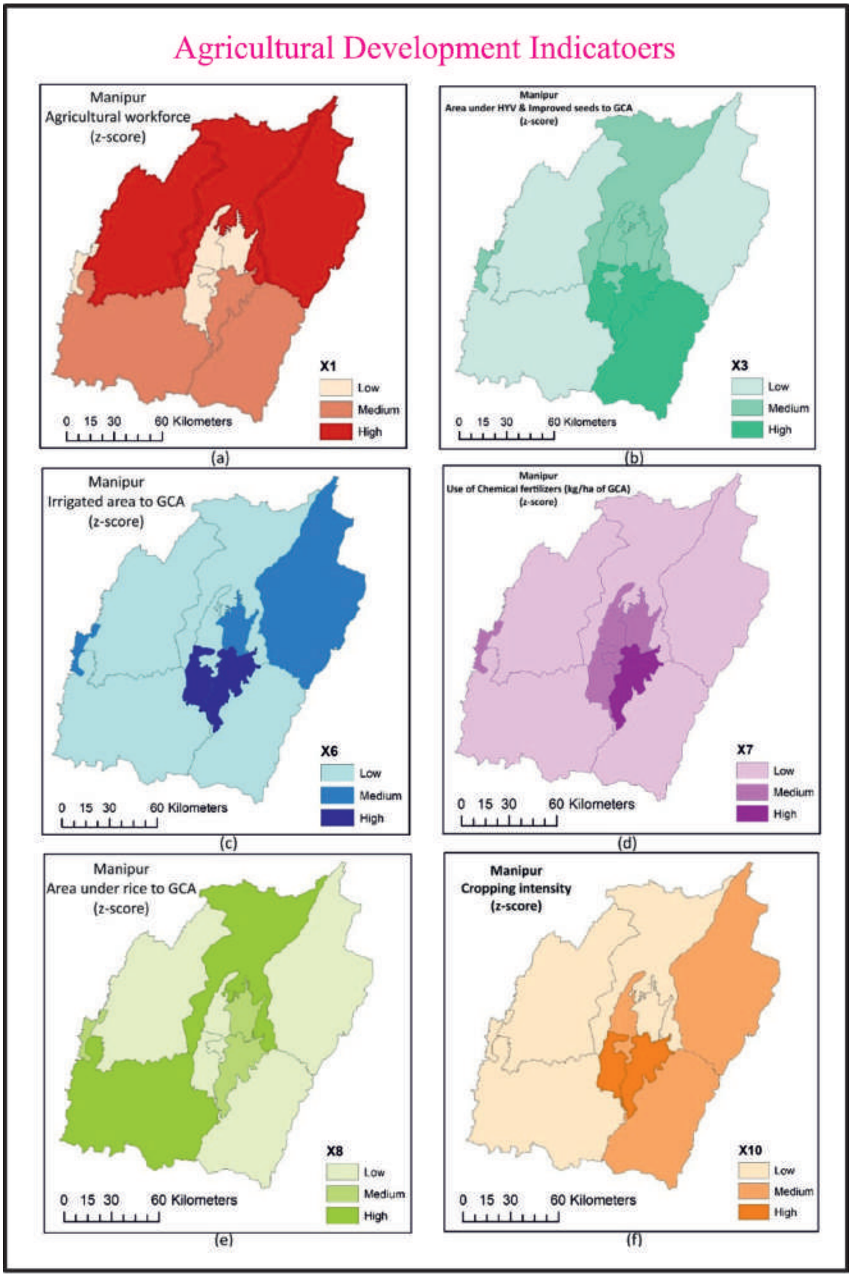
Agricultural Development Indicatoers
Manipur
Agricultural workforce
(z-score)
X1
Low
Medium
High
0 15 30 60 Kilometers
(a)
Manipur
Area under HYV & Improved seeds to GCA
(z-score)
X3
Low
Medium
High
0 15 30 60 Kilometers
(b)
Manipur
Irrigated area to GCA
(z-score)
X6
Low
Medium
High
0 15 30 60 Kilometers
(c)
Manipur
Use of Chemical fertilizers (kg/ha of GCA)
(z-score)
X7
Low
Medium
High
0 15 30 60 Kilometers
(d)
Manipur
Area under rice to GCA
(z-score)
X8
Low
Medium
High
0 15 30 60 Kilometers
(e)
Manipur
Cropping intensity
(z-score)
X10
Low
Medium
High
0 15 30 60 Kilometers
(f)

Fig. 1

total GCA indicates the higher the level of agricultural development. High level of NSA is found in Tamenglong (1.50) and Churachandpur (0.76) districts, while low category is accounted in Thoubal (-1.42), and Bishnupur (-1.37) districts. Despite having higher GCA in the valley districts like Imphal West and Thoubal, due to the practice of mono cropping in these districts the NSA shows comparatively lower to that of the hill districts like Tamenglong and Churachandpur where the land is use more than once for cultivation of crops like maize, potato and vegetables. Consumption of chemical fertilizer is also equally important and plays a crucial role in increasing food grain production. The consumption of chemical fertilizers in different districts ranges from (-0.88 to 1.66) of Z-Score. It shows that very low consumption of chemical fertilizers is found in the hill districts of Manipur. Agricultural Productivity in the production of the principal crop that is the rice, largely depends and is a result a high percentage of area under the rice to the total GCA. It is observed that high percentage of area under rice are found in Senapati and Churachandpur and lowest in the Tamenglong, Chandel, Ukhrul, Bishnupur and Imphal West districts. The variations in the area under rice is controlled by the physical setting and diversification of crops in the region. Production of rice which is the only major crop in the state, in quintal per hectare of agricultural land is also an important measure in agricultural activity, and plays a significant role in assessing the agricultural development. Production of yields is the main purpose of agriculture; higher yield production indicates higher level of agricultural development. The highest level of agricultural productivity is found in Bishnupur district with (1.05) and followed by Senapati district (1.04) of Z-score.

The cropping intensity refers to the use of a field several times during a cropping year. It is also an important indicator it reflects the efficiency and intensity of land use in a given area. It provides valuable insights into the efficiency, productivity, and sustainability of the agricultural systems. The value of cropping intensity in different districts of the state is ranging from -1.30 to 1.54 of Z-Scores. The Highest level of cropping intensity is found in Thoubal district (1.54) and followed by Bishnupur district (1.47) (Table-2). The lowest score is found in Tamenglong district (-1.30). Road length, number of commercial banks, number of power tillers /tractors and number of non-industrial co-operative societies, rural electrification and literacy rate also play a significant role for the development of agricultural activities. Road serves as the arteries for transport of agricultural inputs and agricultural produce to market. The presence of commercial banks helps in supporting the farmers by providing agricultural loans, crop insurance and purchased of farm equipment.

Thus, all the variables adopted has its own importance in determining the level of agricultural development of a region.

Level of Agricultural Development in Manipur

Table-2: Z- Scores for the Level of Agricultural Development in Manipur

Variables	Districts								
	Senapati	Tamenglong	Churachandpur	Chandel	Ukhrul	Imphal East	Imphal West	Bishnupur	Thoubal
X_1	1.25	0.99	0.33	0.43	0.67	-1.35	-1.56	-0.66	-0.10
X_2	1.28	0.74	1.05	-1.38	0.69	-0.43	-1.41	-0.29	-0.24
X_3	-0.66	-2.49	-2.49	0.27	-2.49	-0.39	-1.18	0.25	1.70
X_4	-0.79	-0.76	-0.84	-0.84	-0.87	0.47	1.32	1.15	1.16
X_5	0.67	1.50	0.76	-0.22	-0.10	0.70	-0.52	-1.37	-1.42
X_6	-1.62	-2.59	-2.59	-2.59	-0.12	0.19	-2.59	0.54	1.01
X_7	-0.69	-0.88	-0.76	-0.84	-0.85	0.74	0.58	1.04	1.66
X_8	1.97	-0.64	1.18	-0.61	-1.12	0.27	-0.45	-0.65	0.04
X_9	1.04	-1.88	-0.74	-0.79	-0.06	-0.10	0.65	1.05	0.82
X_{10}	-0.66	-1.30	-0.78	0.09	-0.03	-0.73	0.41	1.47	1.54
X_{11}	-0.47	1.50	0.11	0.84	1.39	-0.78	-0.96	-0.82	-0.83
X_{12}	-0.02	-0.85	-0.30	-0.85	-0.91	0.69	2.23	-0.30	0.31
X_{13}	-0.86	-1.01	-0.94	-0.99	-1.01	0.23	1.59	0.07	0.90
X_{14}	-0.26	-1.31	0.64	-1.71	-0.52	1.00	0.51	0.80	0.85
X_{15}	-0.94	-0.62	-1.71	0.36	-0.59	1.06	0.40	1.04	0.98
X_{16}	-1.75	-0.86	0.88	-0.72	0.68	0.77	1.33	-0.07	-0.26

Source: Authors

To assess the level of agricultural development in the state, all 16 selected variables/indicators have been aggregated. The Z-score values of these variables for each and every district are combined together, and then prepared to calculate the Composite Standard Score (CSS) for the district-wise disparities in the level of agricultural development (Table-2). On the basis of Composite Standard Score values, those all districts of the state have been classified into three categories, viz., High (0.21 – 0.51 Z-Score), Medium (-0.32 – 0.20) and Low (-0.65 – -0.33) in Fig. 2, and Table-3.

Table-3: District- wise Composite Standard Scores of Variables for the Level of Agricultural Development in Manipur

Sl. No.	Districts	Composite Standard Score
1	Senapati	-0.16
2	Tamenglong	-0.65
3	Churachandpur	-0.39
4	Chandel	-0.60
5	Ukhrul	-0.33
6	Imphal East	0.15
7	Imphal West	0.02
8	Bishnupur	0.20
9	Thoubal	0.51

Source: Authors

High Level of Agricultural Development (0.21–0.51)

Only one district namely Thoubal fall under high level of Agricultural development category, out of the total 9 districts. High level of agricultural development in this district is mainly determined by the large portion of area under HYV and Improved seeds, high score of GCA, large portion of irrigated area high proportion of use of chemical fertilizers, high cropping intensity, relatively high use of mechanised farm equipment, relatively high non-industrial cooperative societies and relatively high rural electrification. In this district lower percentage of agricultural workforce, lower rural population, lower rate of net sown area, lower literacy rate are observed (Fig. 2).

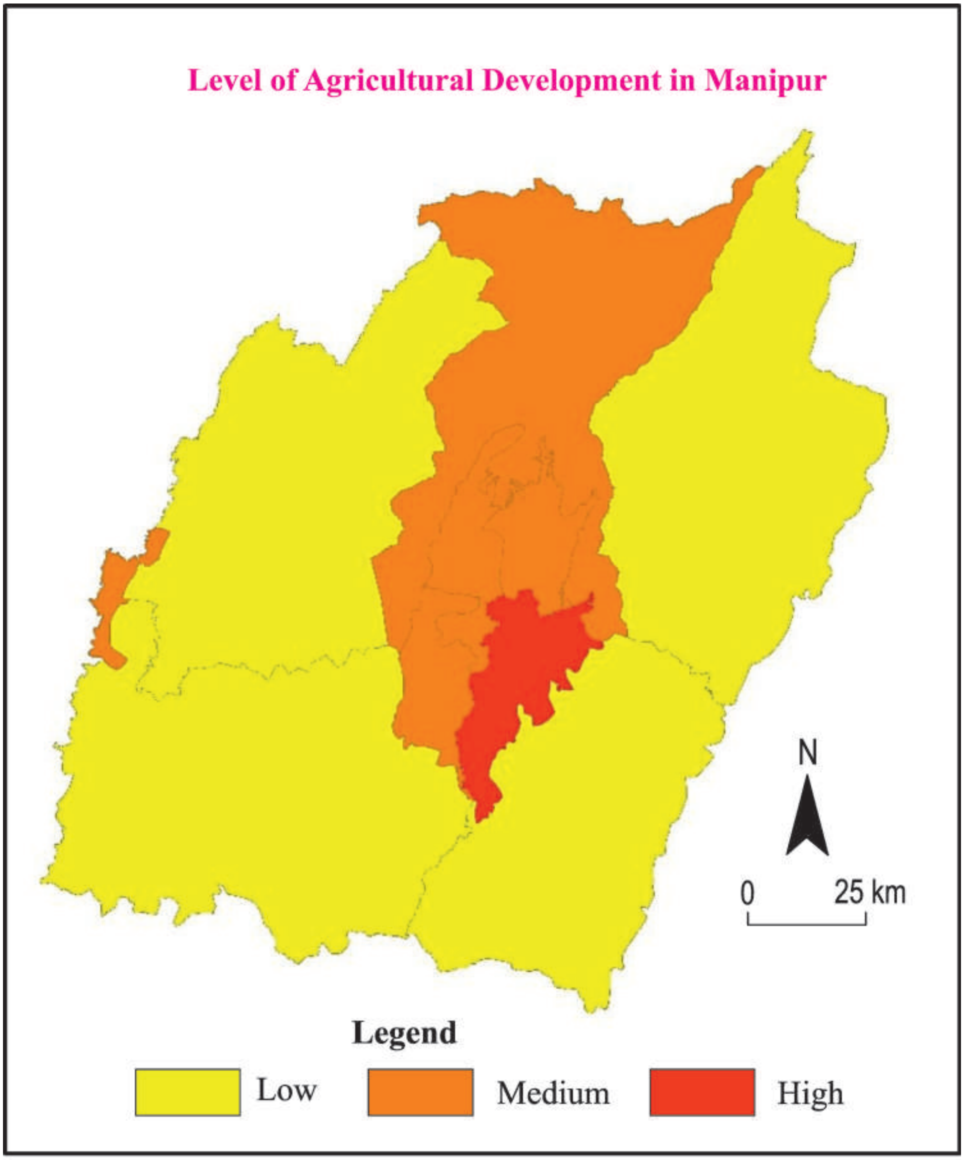
Level of Agricultural Development in Manipur
N
0
25 km
Legend
Low
Medium
High

Fig. 2

Medium Level of Agricultural Development (-0.32–0.20)

Medium level of agricultural development of the state are found in the districts i.e., Imphal East, Imphal -West, Bishnupur and Senapati. In this category, the level of agricultural development is influenced by large rural population, agricultural workforce, area under rice cultivation and rice yield in case of Senapati district and the consumption of chemical fertilizers (NPK), use of modern agricultural tools like power tiller and tractors and number of Co-operative societies, rural electrification and literacy in regard to Imphal East, Imphal West and Bishnupur. Three districts namely Imphal East, Imphal West and Bishnupur districts are located in the Imphal valley, which favourable for the practice of agricultural activities due to fertile soils, favourable agro-ecological conditions as well as improvement of modern technology for agricultural processes and whereas Senapati is a hill district which is comparatively a difficult terrain for agriculture.

Low Level of Agricultural Development (-0.65–0.33)

This category of low agricultural development in the state is observed in Ukhrul, Chandel, Churachandpur and Tamenglong. All these districts under this category are in the hilly tracts. Low level of variables is recorded in these districts which are determined by the lower level of consumption chemical fertilizers (Kg/ha), cropping intensity, lesser use of modern agricultural tools like power tillers and tractors, as well as lower number of co-operative societies, number of commercial banks, lack of irrigation facilities, rice productivity (Production/ha.) etc are recorded in these districts.

Conclusion

The regionalization approaches have been employed to investigate inter-district disparities in agricultural development and to delineate the spatial pattern of agricultural development within the state. This study endeavours to scrutinize inter-district disparities in the level of agricultural development in Manipur, as well as to ascertain the degree and causes of regional disparities in agricultural development within the state. Furthermore, it seeks to examine the spatio-temporal dynamics in the level of agricultural development. However, the study is constrained by several limitations. Firstly, it does not encompass various other indicators such as soil quality, cropping patterns across different districts, and the impact of farmers' holding sizes, thereby leaving room for further expansion of the study's scope. Secondly, the study relies entirely on secondary data sourced from published materials, with no utilization of primary data. Following discussion and analysis of the level of agricultural development in the state based on Z-Scores of 16 selected variables and Composite Standard Score, it is noted that significant disparity exists among districts in the level of agricultural development. Thoubal district exhibits the highest level of agricultural development with a Composite Score of 0.51, whereas Tamenglong district demonstrates the lowest score of -0.65. The higher level of agricultural development in valley districts primarily stems from various factors such as the adoption of High-Yielding Variety (HYV) and improved seeds, use of chemical fertilizers (NPK), availability of modern agricultural tools like power tillers and tractors, cropping intensity, presence of cooperative societies, number of commercial banks, irrigated lands, and rural electrification. Despite favourable agro-climatic and agro-ecological conditions, modern agricultural practices play a pivotal role in enhancing the level of agricultural development in the state. Additionally, the topography significantly influences the overall disparity in agricultural development within the state.

The results indicate that the central valley region exhibits the highest level of agricultural development, following a south-to-north gradient, which aligns with rice yield and the distribution of infrastructural facilities in the state. In the agricultural development index, the greatest variation in Z-Score (4.20) is observed in the percentage of area under HYV and improved seeds, followed by the percentage of irrigated area to Gross Cropped Area (GCA) with a Z-Score of 3.60. Other significant indicators contributing to agricultural development include the percentage of area under rice to total GCA, number of commercial banks, and literacy rate, each explaining variations of above 3.08 Z-Score. The remaining indicators elucidate less than 3.08 score variation in the agricultural development index. The urban population in the state has experienced significant growth, rising from 25.11 percent in 2001 to 29.21 percent in 2011. This rapid urbanization, particularly evident in the valley districts, has prompted shifts in land use patterns. The expanding population not only necessitates increased agricultural development but also poses a threat to the sustainability of subsistence farming. To address these challenges, measures must be taken to reduce agricultural production costs through mechanization and financial support. Priority attention should be given to districts with low levels of agricultural development, with the state providing capital assistance, rural infrastructure improvements, and incentives for crop diversification tailored to local conditions. Urgent action is required to implement proper agricultural planning aimed at enhancing productivity, fostering agricultural development, and narrowing the disparity gap among districts within the state.

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REIMAGINING CITIES AS 'PARASITES' FROM ECOSYSTEM SERVICES' PERSPECTIVE: THE PROBLEM AND VIABLE SOLUTIONS

Prashant Kushwaha, Srabani Sanyal and Shivam Verma

Abstract

The world's cities act as central places providing a multitude of services to the countryside but often fail to produce enough ecosystem services to support their residents. Consequently, they have to rely on the countryside to provide ecosystem services to their inhabitants, effectively becoming 'parasites'. The present article strives to synthesize the views of academic pundits and environmental organizations alike and suggests a multitude of practical approaches to solve the issue of shortage of ecosystem services in cities. Cities experience a shortage of ecosystem services due to a significant mismatch between high demand and minimal supply. To address this issue, increasing the supply of ecosystem services is essential and ways of doing so have been discussed elaborately. Lastly, the role of governments, policies, and citizens in coping with this issue has also been discussed.

Introduction

Cities are characterized by a high density of human population translating to intensive land use and a high proportion of built-up areas. Thus, little space is left for natural areas inside the city, now termed urban ecosystems. Therefore, most of the time urban areas cannot produce enough ecosystem services, like food, fuel, and freshwater, to sustain their population and are dependent on their hinterlands. These ecosystem services i.e., "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment [MEA], 2005) are essential for the survival of human beings on the planet. Ecosystem Services (ES) include Provisioning Services like food, water, and raw materials, Regulating Services like air purification, pollination, and climate regulation, Habitat Services like lifecycle maintenance and gene- pool protection, and Cultural Services like aesthetic information, tourism,

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recreation, etc (de Groot et al., 2010). The shortage of Ecosystem Services in urban areas is a problem of great concern, more so because of rapid urbanization. The proportion of human population residing in cities and towns is increasing at a rapid pace (United Nations, 2018), therefore the demand for Ecosystem Services is bound to rise manifold. An increase in the Standard of Living will also result in increased demand for Ecosystem Services. To cater to this increase in demand, cities will have to reduce their reliance on the countryside.

This paper aims to investigate the problem of the parasitic nature of urban areas concerning ecosystem services. And also, to discover and uncover ways through which urban areas can be made reasonably self-sufficient in terms of Ecosystem Services. A survey of relevant literature served as the foundation of this paper.

Objectives

(1) To investigate the problem of shortage of ecosystem services in cities.
(2) To find out viable and actionable measures for reducing the shortage of ecosystem services in cities.

Database and Methodology

This study is based on theoretical review of relevant literature. Literature search techniques of 'keyword searching' as well as 'cited reference searching (citation mining)' were utilized for the study. Primarily the search technique of 'backward reference searching (chain searching)' was employed. The research databases of 'Google scholar and Web of Science' were used for identifying relevant literature.

Results and Discussion

Cities as Parasites: Recognizing the Problem

Ecologist E.P. Odum was the first one to highlight the problem of the parasitic nature of urban areas. "The great cities are still only parasites in the biosphere" (Odum, 1971). Cities were considered parasites because they could not generate enough "vital resources, namely, air, water, and food" (Odum, 1971), for their residents. And thus, cities have to depend on peripheral rural areas for fulfilling the demands of their population, in this process, there is a greater risk of causing environmental damage to their host, the countryside (Odum, 1971). If any modern city were a closed system lacking any interaction with the outside world, residents of the city would ultimately perish as the natural ecosystems within the city would not be able to generate enough services for its residents (Rees & Wackernagel, 1996). The argument here is that cities can function only due to the input of ES from outside. The city and the countryside are interconnected and cities exhibit complete reliance on the peri-urban areas (Grimm et al., 2008). To get food, water, and other basic resources used within the city, natural ecosystems outside the city's boundaries are needed (Folke et al., 1997). Most cities cannot produce enough ES to fulfil their residents' demands. In fact, the 29 major urban centres in the Baltic Sea Region required areas 565-1130 times greater than their area; to fulfil the need for food, timber, and waste absorption of their population (Folke et al., 1997). Furthermore, generating seafood for residents of the world's megacities requires a quarter of the planet's productive oceans (Folke et al., 1997). Cities thus face a shortage of ES and have to rely on the countryside. This is because, in cities, the demand for ES surpasses its supply by a significant margin (Burkhard et al., 2012). Due to this mismatch cities face a considerable shortage of ES and have to import them from the surrounding countryside. To address the issue of shortage of ES we must first look at the causes leading to their high demand and limited supply in urban areas (Fig. 1).

(a) Causes for the high demand for ES: Urban areas comprise a large number of people living in relatively small areas. Urban residents also have a comparatively higher standard of living than the population of surrounding rural areas. Thus the per capita consumption of natural resources is also high. Demand is also high because urban areas have a high level of pollution translating into a greater requirement for services like air-quality regulation and waste treatment. A large population compounded with high per capita consumption of natural resources leads to a huge demand for ES in urban areas.
(b) Causes for the limited supply of ES: Urban areas are characterized by a high density of population. This leads to a high intensity of land use and simultaneously a high proportion of the built-up area. The city as can be viewed as a cluster of contested spaces. And as urban ecosystems are usually not considered economically profitable when compared to residential and commercial areas very little space is left for them. Also, urban ecosystems are usually not optimized for maximizing the supply of ES. Thus, due to little area under urban ecosystems and their inefficiency in producing ES, the overall supply of ES is pretty low in urban areas.

There are huge demand and limited supply of ES lead to a shortage of ES in urban areas. Thus, there can be two varied approaches to dealing with this problem:

(1) Reducing the demand for ES in urban areas.
(2) Increasing the supply of ES within urban areas.

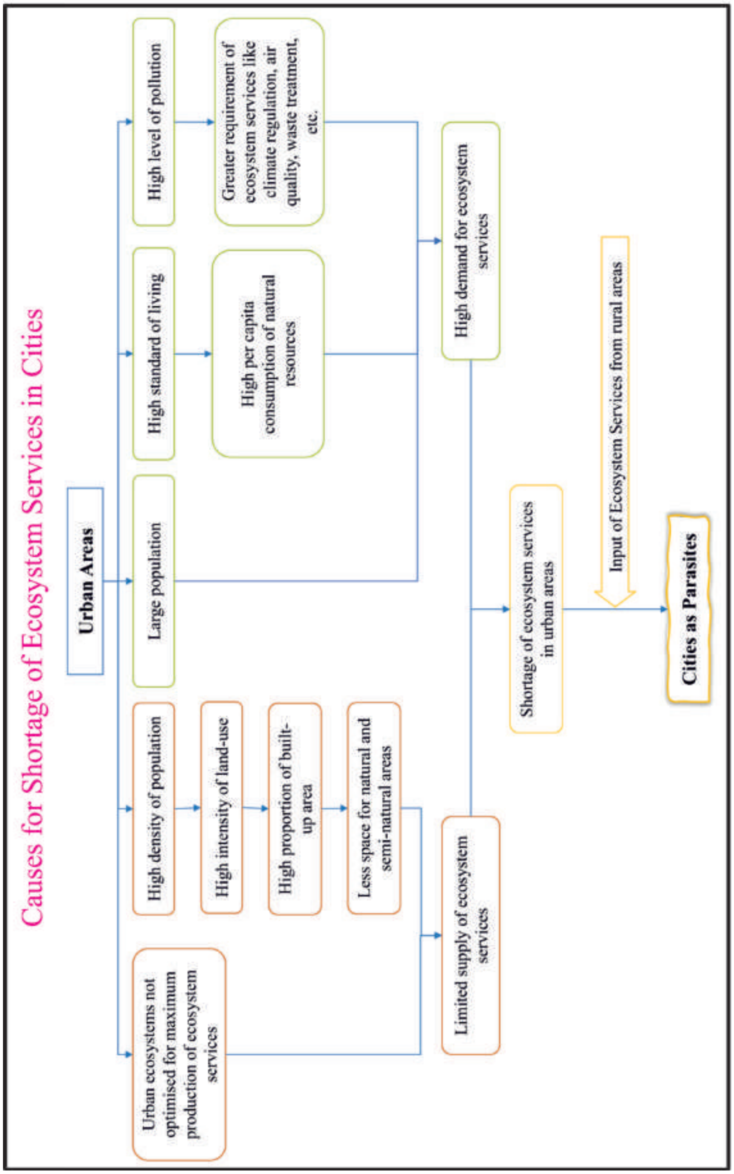
Causes for Shortage of Ecosystem Services in Cities
Urban Areas
Urban ecosystems not optimised for maximum production of ecosystem services
High density of population
High intensity of land-use
High proportion of built-up area
Less space for natural and semi-natural areas
Large population
High standard of living
High level of pollution
High per capita consumption of natural resources
Greater requirement of ecosystem services like climate regulation, air quality, waste treatment, etc.
Limited supply of ecosystem services
High demand for ecosystem services
Shortage of ecosystem services in urban areas
Input of Ecosystem Services from rural areas
Cities as Parasites

Fig. 1

Now reducing the ES-demand in urban areas is next to impossible. Because to do so either we will have to decrease the urban population or reduce their standard of living, both these solutions are simply not feasible. Furthermore, processes such as deurbanization will only shift the place of demand generation and not decrease the demand itself. Therefore, we are bound to focus on the second approach i.e., increasing the supply of ES in urban areas. Now techniques suggested by various scholars for increasing the supply of ES can be categorized into the following groups, namely, increasing the productivity of urban ecosystems and increasing the area occupied by urban ecosystems

Increasing the Productivity of Urban Ecosystems

(a) Focusing on Relevant Services

There are certain services termed 'ES Local' whose benefits are delivered only in their place of creation (Syrbe & Grunewald, 2017). Such services that cannot be transferred easily, must be produced in areas with their demand. Air filtering, water regulation, noise reduction, sewage treatment, microclimate regulation, and cultural values are instances of non-transferrable services pertinent to urban centres (Bolund & Hunhammar, 1999). Urban areas must focus on increasing the supply of these services. Furthermore, different cities may have different problems, thus the services needed and related ecosystems must be decided based on the specific needs of the cities.

(b) Choosing the Right Ecosystems

We already know that space devoted or rather left out for natural spaces in urban areas is limited. And urban ecosystems include a variety of individual ecosystems like "street trees, lawns/parks, urban forests, cultivated land, wetlands, lakes/sea, and streams" (Bolund & Hunhammar, 1999). It is thus very crucial to decide which type of ecosystems will occupy the limited space so that the maximum amount of ES is produced. Two ecosystems that can help in maximizing the supply of ES are Wetlands and Forests. Wetlands are the most valuable terrestrial ecosystems, in terms of the average annual value of ES per hectare (Costanza et al., 1997). In an analysis of the ES relevant to Stockholm, wetlands were the only ecosystem generating all the six assessed services (Bolund & Hunhammar, 1999). Thus, given the high productivity of wetlands, they must be given preference over other urban ecosystems. Similarly, given the variety of ES offered by forests, they become particularly important for urban areas (Escobedo et al., 2019). Urban forests should be the preferred type of ecosystem if we want an abundant supply of ecosystem services. Miyawaki forests especially can help provide much-needed ES as they grow faster, are denser, and contain greater biodiversity than regular forests (SUGi, n.d.).

Restoration of Degraded Ecosystems

Restoration of degraded ecosystems can lead to an increase in their capacity to supply ES. Wetland restoration greatly improves phosphorus and nitrogen retention resulting in an increase in soil organic carbon, soil permeability, and species diversity of native plants (Tomscha et al., 2021). Similarly, river restoration aids in improving the ecological condition and positively affects ES, especially regulating and cultural services (Kaiser et al., 2020). Thus, the restoration of degraded ecosystems is essential for increasing the supply of ES.

Increasing the Area Occupied by Urban Ecosystems

Establishing the Value of ES and urban ecosystems: We can convince the government and stakeholders to increase the area under urban ecosystems only if we can show them the value of urban ecosystems, preferably in monetary terms. Mapping and detailed quantification of ES are the primary necessities for incorporating ES into environmental organizations, and the decision and policy-making processes (Daily & Matson, 2008). Ecosystem Services Valuation (ESV) is a tool that can help in persuading society to appreciate the importance of ES (Liu et al., 2010). Lack of valuation is attributed as the root cause for the deterioration of ecosystems (TEEB, 2008).

Role of Cultural and Religious Values: Cultural Ecosystem Services refer to the nonmaterial benefits like spiritual nourishment, cognitive development, introspection, leisure, and aesthetic experiences that humans derive from ecosystems (MEA, 2005). These cultural and spiritual values of ecosystems can be used as important motivators in environmental conservation (Verschuuren, 2007). Furthermore, all major religions of the world have values of environmental protection enshrined in them (UNEP, n.d.). Such religious and cultural values can be utilized in the conservation of biodiversity and judicial management of ecosystems (Saini et al., 2011). If used wisely, these values can help immensely in the preservation, restoration as well as expansion of urban ecosystems (Fig. 2).

Green infrastructure over grey infrastructure: Cities generally have three types of infrastructure: grey (built-up area/ artificial surface), blue (water bodies of various kinds), and green (areas occupied by trees) (Salbitano et al., 2016).

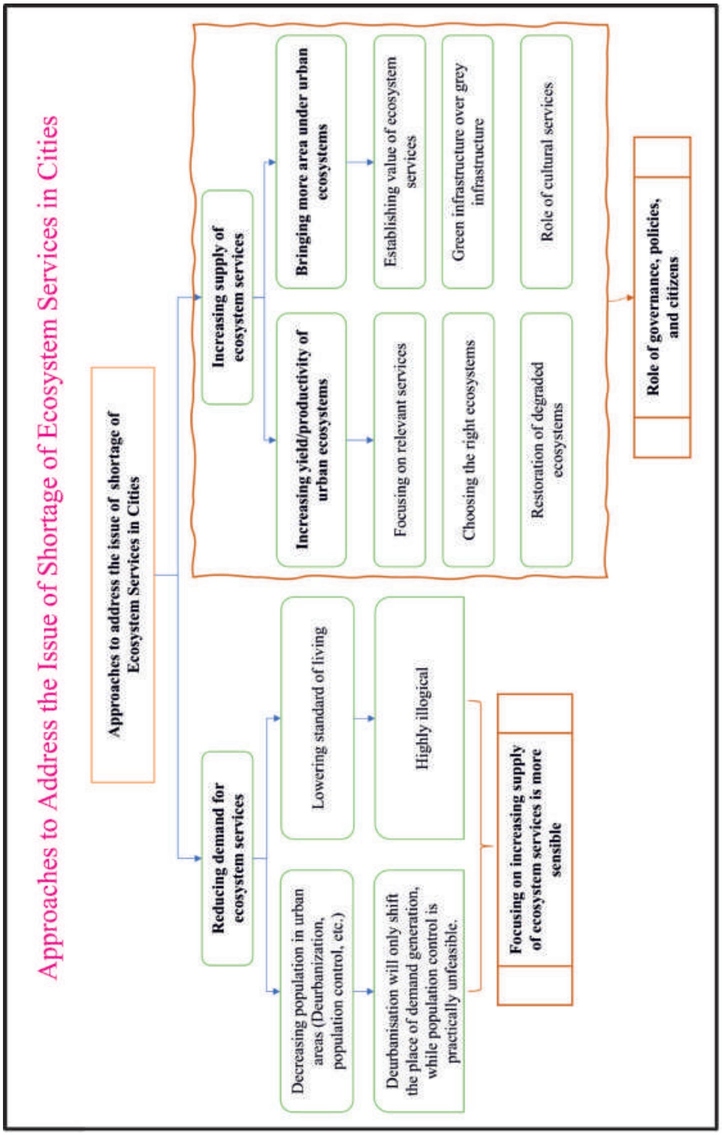
Approaches to Address the Issue of Shortage of Ecosystem Services in Cities
Approaches to address the issue of shortage of Ecosystem Services in Cities
Reducing demand for ecosystem services
Increasing supply of ecosystem services
Decreasing population in urban areas (Deurbanization, population control, etc.)
Lowering standard of living
Deurbanisation will only shift the place of demand generation, while population control is practically unfeasible.
Highly illogical
Focusing on increasing supply of ecosystem services is more sensible
Increasing yield/productivity of urban ecosystems
Bringing more area under urban ecosystems
Focusing on relevant services
Choosing the right ecosystems
Restoration of degraded ecosystems
Establishing value of ecosystem services
Green infrastructure over grey infrastructure
Role of cultural services
Role of governance, policies, and citizens

Fig. 2

Now as the majority of space in urban areas is occupied by grey infrastructure, negligible space is left for blue and green infrastructure.

Traditionally green infrastructure was developed over areas occupied by soil, but this isn't the case anymore. Agriculture in urban areas for example, is being transformed by what is termed Zero Acreage Farming (Z Farming) which is a type of urban farming that doesn't require open spaces or agricultural land (Buehler & Junge, 2016). Thus, now we can have green infrastructure over grey infrastructure, which will help a lot in increasing the area occupied by Urban ecosystems.

Role of Governance, Policies and Citizens

Role of Governance and Policies: Valuing urban ES and integrating their diverse values into governance and urban planning is crucial in the preservation of urban ecosystems (McPhearson et al., 2015). Furthermore, there must be a collaboration between researchers and decision-makers so that knowledge generated from research can be effectively put into practice (Barton et al., 2018). Thus, the government should try to actively collaborate with the academic community. Moreover, in budget-constrained situations, municipal officials may consider developing opportunities for citizens' participation in the tree-planting process (Giergiczny & Kronenberg, 2014). The local government of New York City for example is pioneering in this direction by offering incentives to the citizens for rooftop farming (Green Infrastructure Grant Program, n.d.). Such schemes which provide monetary compensation to individuals for undertaking initiatives to improve the supply of ES are now termed 'payment for ecosystem services (PES) schemes' and have shown promise as enduring funding sources for environmental conservation (WWF, n.d.). Governments can also initiate citizen involvement in conservation projects by utilizing poverty alleviation and livelihood creation schemes in building and restoring green and blue infrastructure (Ernstson et al., 2010).

Role of Citizens: In a survey of residents of Lodz, Poland, it was found that citizens of the city agreed in general to the necessity of planting trees (Giergiczny & Kronenberg, 2014). Similarly in an assessment concerning residents of Berlin and Salzburg cities, it was found that urban green spaces are highly valued and play a critical role in ensuring human wellbeing (Voigt et al., 2014). Thus, it can be said that urban residents highly value urban green spaces. Now as a majority of the governments in the world are democratic or partially democratic (Desilver, 2019), the will of the people becomes crucial in the decision-making process.

Convincing governments and urban planners about the need for urban ecosystems will be much simpler if they know that urban citizens keep urban greens in high regard. Also, citizens must persuade the government to make ecologically sensible policies. City residents must also actively participate in efforts to build blue-green infrastructure. Apart from environmental benefits citizen participation in such efforts can also provide a variety of social benefits (Sommer et al., 1994).

Nexus between Governments and Citizens: Citizens can contribute to maximizing the production of ES either by pressurizing their respective governments to do so or by getting involved in relevant projects especially when the local bodies' resources are limited. On the other hand, Governments must account for citizens' views in support of urban ecosystems during policy making. Also, wherever necessary governments can promote citizens' involvement in restoring green and blue spaces through incentives, livelihood creation schemes, etc. Thus, there must be mutual understanding and cooperation between both these stakeholders.

Conclusion

Thus, Cities generally have limited ES production and depend on the countryside for fulfilment of the demand for ecosystem services of their residents. The scarcity of ES in cities is due to:

(1) Huge demand for ES due to high population density, a relatively higher standard of living, and high levels of pollution
(2) Limited supply of ES due to inadequate space under urban ecosystems and low productivity of urban ecosystems.
(3) In this study, we concentrated on increasing the supply of ES to address the issue of ES scarcity in cities. We have summarized the solutions offered by different scholars and organizations and developed two general approaches:
(4) Increasing productivity of urban ecosystems which can be achieved by focusing on relevant services, utilizing highly productive ES, and restoration of degraded ecosystems.
(5) Increasing the area under urban ecosystems by establishing the value of ES, building green infrastructure over grey infrastructure, utilizing the cultural value of ecosystems, and accounting for substitutes of ES and lastly, Lastly, we have examined ways through which governments and residents can contribute to increasing the supply of ES and solving the problem of shortage of ES.

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MAPPING THE RESEARCH TREND OF BIG DATA ANALYTICS IN THE FIELD OF BUSINESS MANAGEMENT AND ACCOUNTING DISCIPLINE: A BIBLIOMETRIC ANALYSIS

Dr. Rekha Dhingra, Deepa and Aniket Saini,

Abstract

In the contemporary landscape, big data has emerged as a pivotal asset for businesses, driving a digital transformation. Business analytics stands out as the predominant tool for strategic decision-making in company management research. This study aims to analyze publications on big data analytics within the realms of business management and accounting, focusing on identifying key themes, assessing research trends, and highlighting significant contributions. Findings reveal an average of 3.09 authors per publication, with a 36.4% international collaboration index. The United States, India, and the United Kingdom have emerged as leading contributors to big data analytics research. Four primary research clusters are identified: the "red-colored cluster" addresses factors influencing big data analytics, the "blue-colored cluster" delves into technical aspects, the "green-colored cluster" explores the role of big data analytics in business, and the "purple cluster" signifies the evolving landscape of big data analytics, driven by the proliferation of vast data volumes.

Introduction

In the dynamic landscape of management and accounting, the infusion of data analysis has emerged as a catalytic force, reshaping traditional paradigms and propelling these fields into an era of unprecedented insights and opportunities. The sheer volume and diversity of data available today have necessitated a departure from conventional decision-making methodologies, compelling researchers and practitioners alike to embrace data-driven approaches. In very simple terms, 5 Vs are used to define Big Data: volume, variety, velocity, value, and veracity (Blackburn et al., 2017). Volume refers to data quantity, variety to data types, velocity to data

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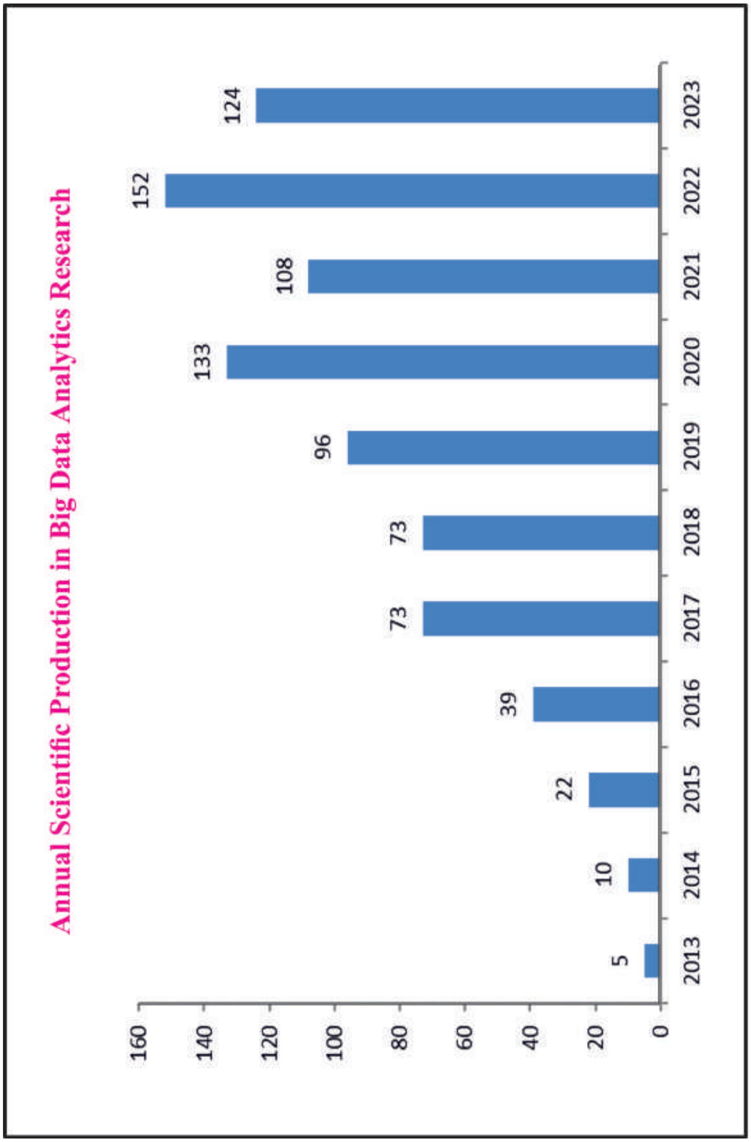
generation speed, value to the benefits from data, and veracity to data accuracy. The rise of big data analytics makes a turning point in IT's impact on business, requiring advanced analytics to uncover patterns within its vast volumes, velocity, and variety. (Hashem et al., 2015) describes big data analytics as a collection of techniques and tools that combine novel forms to reveal hidden values in a variety of intricate, large-scale data sets. Davenport (2006) argues that analytics-driven organizations outperform their counterparts, citing examples of companies leveraging data to optimize supply chain management, enhance customer experiences, and streamline operational processes. According to (McAfee & Brynjolfsson, n.d.), "big data" can completely change the way decisions are made by providing better performance evaluation tools and increased visibility into business operations. BDA is transforming management by enabling firms to use data as a strategic tool for navigating complexity and uncertainty. This marks a break from the past. In accounting, BDA goes beyond traditional reporting, enabling predictive analytics, risk management, and fraud detection. According to Cockcroft & Russell (2018) , big data analytics enables accountants to go beyond historical analysis, offering real-time insights into financial performance, identifying anomalies, and regulatory compliance. Despite many studies, big data analytics still needs exploration in Business Management and Accounting to gain better insights. At the intersection of innovation and information, this bibliometric analysis explores data analysis in management and accounting.

Objective

The objective of this study is to map the research evolution and identify key authors, journals, and institutions. Further to get research clusters in big data analytics through keyword analysis.

Database and Methodology

The bibliometric analysis is an effective technique to examine the patterns and traits of previously published articles in any scientific subject, as well as with citation and co-citation analysis. Furthermore, it will be useful in determining whether or not a certain subject of study has an established school of thought. Fig. 1 gives information about the overview of the methodology adopted in this study that is influenced by previous research (Sahoo, 2022), (Faruk et al., 2021). The authors also sought to look into how big data analytics have evolved theoretically and practically in the fields of business management and accounting discipline. Out of 4531 publications in the Scopus database, only 835 are relevant to the business


Annual Scientific Production in Big Data Analytics Research
160
140
120
100
80
60
40
20
0
2013
2014
2015
2016
2017
2018
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2021
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2023
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133
108
152
124

Fig. 1

management and accounting discipline. The reason behind limiting this study to only business management and accounting disciplines is to identify the gap for future researchers who are pursuing their research in the same discipline. Since the author just used a single keyword "Big Data Analytics," to retrieve the data, all types of documents (i.e., note review, short survey, editorial, conference review, conference paper, book chapter, article, and book) are included in this study as well as to proper analysis the big data analytics research in this field. Since the authors sought to take into account both highly cited publications and articles with few citations, the complete range of citations from 0 to 1066 was taken into account for the "total citation" metric. This aids in differentiating between superior and subpar research projects. Additionally, every source was taken into consideration regarding the "source by Bradford Law Zones." Finally, the bibliometrics package of R programming was used to analyze the data that had been retrieved from the Scopus database.

Result and Discussion

This study offers the results of a bibliometric analysis of 835 big data analytics-related documents published between 2013 and September 2023 in 373 sources, with a growth rate of 37.86% each year. Table-1 gives the summary of the literature available on the Scopus database related to big data analytics (Table-1). The average number of citations for articles published during this time period in the Scopus database was 35.92. The higher average number of citations per document indicates a rapid growth in the body of scholarly literature in the field of big data analytics. The results further showed that in 2018, various authors contributed to big data analytics in the areas of accounting and business management throughout this time. Additionally, there were 113 documents with a single author, while there were 3.09 co-authors per document. This suggests that a considerable amount of research studies are conducted in conjunction with other authors in the development of big data analytics, a finding that is corroborated by the collaboration index of 36.4%. However, a sizable number of publications with just one author also exists.

Performance Analysis

The trends in the yearly scientific output in the area of business, management and accounting discipline Fig. 1. The history of the growth of publications can be roughly divided into two phases, each having its own annual publication trends. The research on big data analytics had started in 2013. However, throughout the first

Table-1: Overview of Data

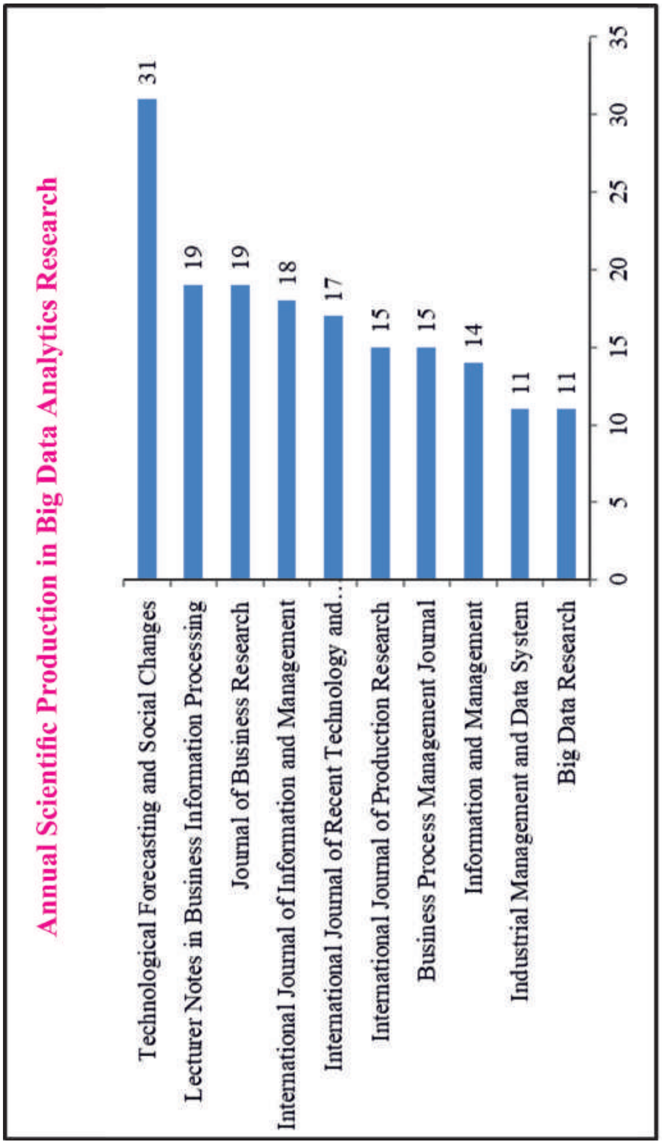
Description	Results
Time span	2013:2023
Documents	835
Sources (Journals, Books, etc)	373
Average citations per doc	35.92
Annual Growth Rate %	37.86
DOCUMENT CONTENTS	
Author's Keywords (DE)	2051
Keywords Plus (ID)	2381
AUTHORS	
Authors	2081
AUTHORS COLLABORATION	
Co-Authors per Doc	3.09
Single-authored docs	113
International co-authorships %	36.4

Source: Author's own creation

four years (2013–2016) the research on big data analytics is entirely overlooked. Accordingly, the actual proliferation started after 2016, which corresponds to the second phase (2017–2023), and as time has gone on, research in this area has increased tremendously. This surge can be connected to the rise in the number of people using the internet and AI. 61% (517) of the research papers on big data analytics were published in Scopus over the 4-year (2020-2023). This depicts those big data analytics is a hot topic nowadays.

Relationship between Authors, Keywords and Sources

Fig. 2 shows three field plot analyses that illustrate the association between authors, keywords, and sources, lists the authors' names, the center column lists the most frequently used keywords, and the right column lists the name of the most fruitful journal. This confirms that most of the authors have considered "data analytics" and "big data" as their keywords. Nonetheless, other research publications have also utilized the terms "advanced analytics," "decision making," "big data analytics," and "supply chain," among many other closely related terms.


Annual Scientific Production in Big Data Analytics Research
Technological Forecasting and Social Changes
Lecturer Notes in Business Information Processing
Journal of Business Research
International Journal of Information and Management
International Journal of Recent Technology and…
International Journal of Production Research
Business Process Management Journal
Information and Management
Industrial Management and Data System
Big Data Research
31
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18
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15
15
14
11
11
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20
25
30
35

Fig. 2

It was discovered that earlier researchers who used the keyword "big data analytics" also used the keywords mentioned above. However, the data also makes it evident that the authors' attention is focused more on "big data" and "data analytics" than on any other phrases. The widespread use of terms like "big data" and "data analytics" when contrasted to alternative semantic terminologies that may also be used to express the same thing supports the reasoning for this consideration. Nearly all journals made an equal contribution, however some journals such as Technological Forecasting and Social Change and Information Journal of Production Research are leading the way in this field's progress. Despite being a very prominent field within data analytics and large data, big data analytics remains unexplored. Future scholars can, therefore, add to this field.

Performance of Academic Journals

"Technological Forecasting and Social Changes" is the most effective journal in the publication of big data analytics. Within the time frame, this journal alone published 31 research papers, which is approximately 3% of all publications. "Journal of business research" has published 19 researches and "Lecturer Notes in Business Information Processing" has also published 19 studies on this topic. There are several prominent journals that are influential in publishing big data analytics research, including "International Journal of Information and Management", "International Journal of Recent Technology and Engineering", "Business Process Management Journal", "International Journal of Production Research", "Journal of Information and Management", "Big Data Research", and "Industrial Management and Data System".

Source Growth of Digital Marketing Over Time

As we stated previously in this paper, "Technological Forecasting and Social Changes" has made the most contributions to the research of big data analytics. From the beginning, the contribution of sources like "lecturer notes in business information processing" has grown tremendously. From 2015 to 2023, "Journal of Business Research" was identified to be the journal of the most contributions to academic works on big data analytics. However, other journal, such as "International Journal of Recent Technology and Engineering" accepted paper from 2017 but their contribution has decreased significantly after 2020 (see Figure 5). Prior to 2019, the "International Journal of Information and Management" neglected to publish in the domain despite having continued to make major contributions to the publication.

Contribution by Countries

The United States, the United Kingdom, and India have made the largest contributions therefore it seems reasonable that these nations' researchers would collaborate the most. However, Australia as a nation hasn't made a lot of contributions, although a few of its authors have worked closely with authors from other nations. From an analytical perspective, it can be seen that North America and Europe made the largest contributions, followed by Asia. However, South America and Africa have made absolutely no significant contributions. The distinct economic and demographic progress of individual nations accounts for this phenomenon. The majority of South American and African nations are not as developed as other contributors. The "North-South gap" is another intriguing conclusion made in this investigation. Research indicates that countries located north of the equator contribute more than those located south of the equator.

Keyword Analysis

Four prominent research clusters in big data analytics were found by this bibliometric study, as Figure 7 shows. Every cluster differs from the others in a noteworthy way. The investigation revealed that the largest cluster in big data analytics is the red-colored cluster. In addition, which keyword was discussed the most is expressed by the keyword analysis. In these, 835 papers are published from 2013 to 2023 in Scopus. The main keywords in this context are big data, which is followed by terms like forecasting, technology, social networking, online social networking, social media sales, and the internet. This cluster analysis produced yet another astounding discovery. e.g., four clusters represent four different facets; the “red-colored” cluster denotes the different factors that affect big data analytics, while the blue-coloured cluster signifies the technical aspects related to big data analytics, and the “green colored” cluster represents the role of big data analytics in business. The purple cluster depicts the recent development of big data analytics because of the widespread creation and analysis of massive data (i.e., machine learning and data visualization).

Conclusion and Implications

In conclusion, it can be said with certainty that the field of big data analytics research began to expand in 2013. There are now four main study themes, including the “red-coloured” cluster represents the different factors that affect big data analytics while the “blue- coloured” cluster represents the technical aspects related to big data analytics, and the "green-coloured" cluster represents the role of big data analytics in business. Due to the widespread usage of large data creation, the purple cluster show that big data analytics has recently seen tremendous development, making it an important field for both researchers and policymakers. The countries that contributed most nationally to this progress were the UK, India, and the USA. Over the past six years, "big data analytics" has gained popularity. The shift from a physical to a virtual environment for marketing and sales is what has caused a revolution in the business world thanks to electronic commerce. Digital information and databases are now a fundamental part of this issue. (Hariri et al., 2019). At last, the main limitation of this paper is the exclusion of articles from other databases like Web of Science and PubMed. Additionally, the keywords search can be extended to more words, as opposed to only "big data analytics," as used in the paper. As well as why countries like Australia, Canada, Germany, France, Russia, and others have lagged behind in the study of Big Data Analytics.

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GEOSPATIAL ASSESSMENT OF LAND USE AND LAND COVER CHANGE DETECTION IN JODHPUR CITY, RAJASTHAN

Amjed Ali, Dr. Kheraj and Arshad Ahmed

Abstract

Rapid urbanization in Jodhpur is causing degradation of the environment and quality of life. Remote sensing data, GIS Techniques were used to analyse the land use and land cover changes in the city. Population growth and rapid social and economic development are the primary drivers of these changes. Effective planning is urgently needed to protect the existing natural Resources. Landsat-5 Thematic Mapper (TM) images taken for 1991, 2001, and 2011, as well as Landsat Operational Land Imager (OLI) 8 images taken for 2021 with a 30-meter spatial resolution. Erdas Imagine 14 software was used for image processing, classification and change detection. Raster images were classified in Erdas Imagine 14 software using an unsupervised classification method. Based on the change detection analysis of LU/LC for four time periods, the built-up area and mining area have increased significantly, and barren lands are being transformed into urban and cultivated areas. It is also observed that due to rapid urbanisation in Jodhpur City, a substantial amount of agriculture and vegetation has declined across the timeline. It is found that the direction of built-up growth is predominant in the South-west direction, while the cultivation is progressing along the Southerly direction. These changes underscore the need for sustainable development practices to manage urban growth effectively.

Introduction

Rapid urbanization leads to uncontrolled physical expansion and constant shifts in land use and cover (LULC). Urbanization in several developing nations shows that urban physical growth has occurred at the fringes. Urbanization has led to the depletion of water bodies, natural vegetation cover, and arable land, and the destruction of habitats, affecting the climate at local, regional,

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and global scales (Akshatha & Shankar, 2020). The use of remote sensing (RS) is the most effective technique available for tracking Spatiotemporal shifts and comprehending the dynamics of land use. GIS and remote sensing approaches are more effective than traditional methods because they deliver high-resolution (HR), instructive, precise, and up-to-date information to study landform dynamics faster, cheaper, and more accurate,(Belal & Moghanm, 2011; Jensen, 1984; Jensen & Cowen, 2011; Kachhwala, 1985).It is important to understand how land use and land cover (LULC) evolves to make the best choices for natural resource planning, restoration, and management, (Ahmad & Quegan, 2012; Homer et al., 2007). The land covers in Jodhpur are experiencing significant changes due to the impacts of urbanization, industrialization, infrastructure expansion, and the decline of arable land and green space. The dynamics of land use and land cover are widespread, significant, and often occurring processes driven by human activities. These dynamics result in changes that impact society,(Agarwal et al., 2002; Saharan et al., 2018). The shifting land use and cover in Jodhpur's surroundings threaten the sustainability and livelihood of the local population(Mainuri et al., 2019).

Over time, the urban area has expanded, leading to a reduction in the presence of native vegetation, agriculture, and wildlife habitats. The migration of people to the desert town of Jodhpur is mostly caused by factors such as changing resources, the availability of drinking water, and improvements in infrastructure amenities. Over the past three decades, there has been significant growth in the expansion of Jodhpur, primarily driven by the influx of tourists and locals shifting to the city and the Thar Desert. The migration of people to the desert town of Jodhpur is mostly caused by factors such as changing resources, the availability of drinking water, and improvements in infrastructure amenities. Over the past three decades, there has been significant growth in the expansion of Jodhpur, primarily driven by the influx of tourists and locals shifting to the city and the Thar Desert. Some studies have documented land use and land cover (LULC) changes in Jodhpur city. They examined land use dynamics at the rural-urban fringe, the relationship between LULC and land surface temperature (LST), and Normalized vegetation Index (NDVI) detection of land cover change, LULC and its effects on water quality, and urban forestry. have discussed the dynamics of the core (Borana & Yadav, 2017b, 2017b, 2017a; Ram & Sheikh, 2023)However, most of these studies are either outdated or mostly focused on the relationship between LULC and LST, while our research take into account the influence of Urbanization and Infrastructural development as the main factor driving urbanization, which leads to overall changes in recent LULC dynamics.

Study Region

Jodhpur is located in the Thar Desert area of western Rajasthan, at the latitude of 26°1 8´ North and 73°1´ East longitude (Ram & Sheikh, 2023; Yadav & Borana, 2017). The population of Jodhpur in 2011, according to the Census India, 2011 was 1.3million. The city of Jodhpur falls in a semi-arid climate region. Jodhpur is the second largest city in Rajasthan. The hills in the north and northwest define the region's overall topography. The current population is 1.15 million people, and the area is 230 square kilometres. In addition, Jodhpur has served as one of the economic engines for the state of Rajasthan. Jodhpur is the most populous city in Western Rajasthan. Jodhpur remains one of the most rapidly growing cities in India. It is the largest city in western Rajasthan and exhibits the highest degree of urban development among all the desert districts of Rajasthan. Jodhpur lies at the top among all, with 34.3 % of the urbanization level. For the past three decades, there has been a considerable increase in industrial activity in and surrounding Jodhpur. The rapid increase in the urban population, together with the expansion and development of cities, is putting strain on the city's ecological and infrastructural capacity to support this growth. Currently, the city is experiencing issues related to insufficient infrastructure, unplanned settlements, traffic congestion, flooding caused by rainstorms, and low-lying areas due to inadequate stormwater and sewage drainage systems (Wang et al., 2021a) The city of Jodhpur is situated at a greater altitude, ranging from 235 to 352 meters (amsl). Jodhpur's topography is generally arid and rocky, located in the Thar Desert region, with terrain shaped by ancient geological formations. The city is surrounded by isolated hills and ridges, with notable rocky outcrops like Mehrangarh Fort's hilltop, which rises prominently in the landscape.

Objectives

This study aims to create a land cover map of Jodhpur City at different significant periods to identify changes that occurred between 1991 and 2021 using remote sensing and GIS Techniques.

Database and Methodology

In this study, primarily two types of data were used: remote sensing data and topographic maps. Digital remote sensing data were obtained from National Remote Sensing Agency (NRSA), Government of India, Hyderabad. Topographic map obtained from Survey of India, Hyderabad, (https://onlinemaps.surveyofindia.gov.in/) originally surveyed and prepared in 1975; it was digitized by scanning.

The topographic maps were georeferenced using ArcGIS software and special analyst tools with the help of longitude and latitude, which defined the boundaries of the study area. Toposheets and satellite data such as LANDSAT-5 TM 1991, 2001, 2011 and LANDSAT-8 OLI/TIRS for 2021, (From US Geological Survey (USGS) http://earthexplorer.usgs.gov) were used to detect land use change. Satellite images were geo-referenced using ERDAS (Earth Resource Data Analysis System) Imagine software. A False color composite was created for the study area by combining different bands of satellite imagery, which was extracted by sub-setting the images. Finally, the images were digitized using ArcGis software in a GIS environment and displayed as polygons corresponding to different land use and land cover types. The LULC map were classified into six classes: water bodies, vegetation, agriculture, built-up areas, barren land, and mining area. Raster images were classified in Erdas Imagine 14 software using an unsupervised classification method. Classification accuracy was assessed using both areal and spectral features, with accuracy assessed using the kappa index and confusion matrix. About 200 training samples were randomly selected from the land use map to evaluate the accuracy. To fulfil the aims of the research, the Landsat 4-5 TM and LANDSAT-8 OLI/TIRS multi-temporal cloud-free images retrieved for the period 1991-2021 were utilized to produce the LULC maps.

Results and Discussion

Landuse/Landcover Analysis

In general, Jodhpur City has had significant alterations in land use and land cover throughout the past three decades over its whole area. However, the changes have taken place, particularly in the lowland Center and southwestern areas of the city. Validating the model is a crucial prerequisite for research that aims to forecast changes in LULC (Appiah et al., 2017).The Kappa statistic is widely recognized as one of the most prominent metrics for measuring the prediction ability of a model, (Appiah et al., 2017; Hua, 2017). Kappa values have been classified into various categories by,(Hua, 2017; Maingi et al., 2002): < 0 indicates no agreement, 0.0-0.41 represents a poor agreement, 0.41-0.60 represents a reasonable arrangement, 0.60-0.80 signifies a significant agreement and 0.81-1.0 signifies an perfect arrangement. The Kappa analysis performed in this research produced values that were significantly higher than 70, which deemed them to be significant predictors,(Maingi et al., 2002; Manonmani & Suganya, 2010). The results and discussion resulting from the present research are explained in the following subsections (Fig. 1).

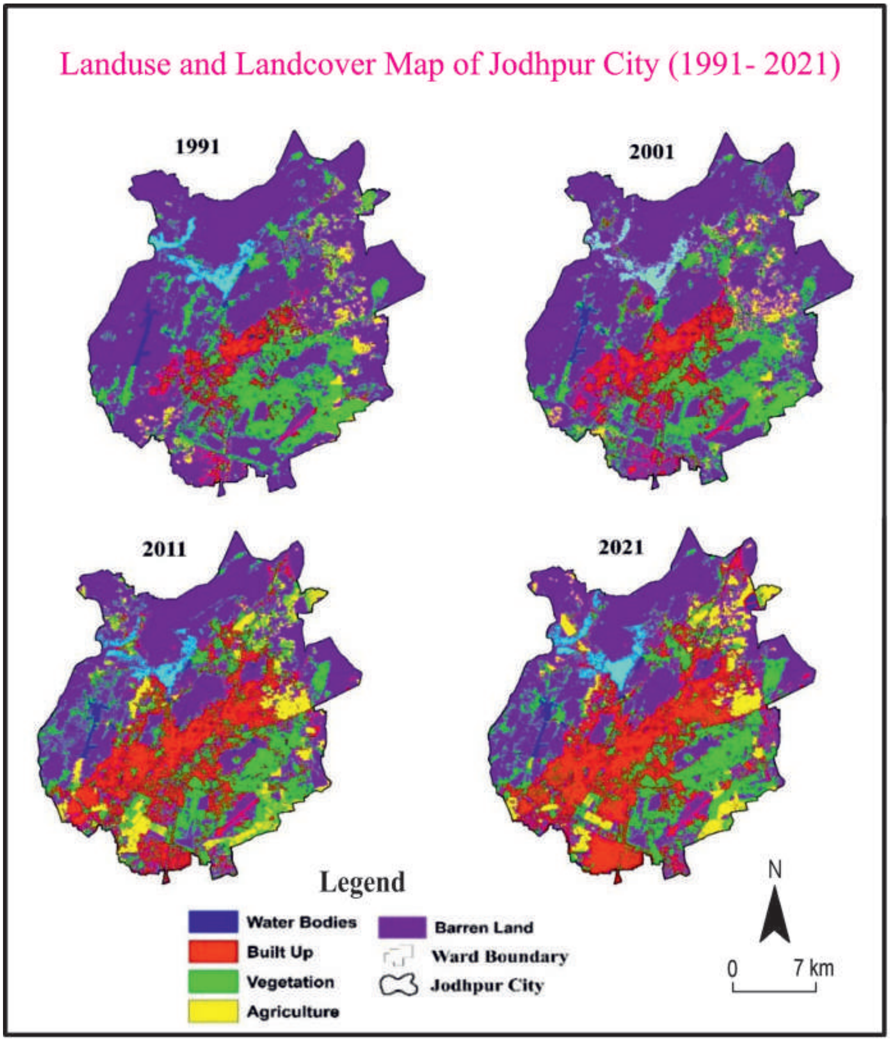
Landuse and Landcover Map of Jodhpur City (1991- 2021)
1991
2001
2011
2021
Legend
Water Bodies
Built Up
Vegetation
Agriculture
Barren Land
Ward Boundary
Jodhpur City
N
0
7 km

Fig. 1

Landuse Landcover Change

LULC analysis enables us to comprehend biophysical alterations, including the depletion of productive environments and biodiversity, the decline of ecological quality, and the loss of vegetation cover and agrarian areas, which are the key factors to consider while developing sustainable cities, (Manonmani & Suganya, 2010; Wang et al., 2021b). The latest remote sensing and GIS methods were applied to measure LULC in Jodhpur city. Six land use land cover types were classified: water body, Built-up, Vegetation, Agriculture, barren land and Mining area (Fig.1). We explored the notable transformation between 1991 and 2021 (Fig. 1 Table. 1). Vegetation is mostly confined to Southeastern lands located at lower grounds near water bodies with some spotty patches scattered all over the city. Barren land is mostly the rocky dunes found scattered across the city, but most of the barren land is found in the north and northwest of the town. While agriculture is confined to the east, north-east and certain patches are found in the south and southeast of the city. In 1991, largest land use types were Barren Land (67.7%), followed by vegetation (18.6%), and Built-up (6.16%). By 2021, the city's built-up area increased the maximum from 13.42 km to 54.49. km (24.99%), reflecting an overall increase of 18.83 % (41.07 km) in 2021. The land use types area was calculated by analysing the classified images of 1991(a), 2001(b), 2011(c) and 2021(d) shown in Fig. 1. Urban growth is primarily found in the central area of the city and gradually extends towards the outskirts,(Fig. 1) The urban and vegetated areas of Jodhpur City have increased, whereas there has been a decline in areas such as rock barren land and other areas (Saharan et al., 2018). There has been a prominent growth in the built-up. Conversely, other areas, such as cropland and scrubland, have decreased since 2011. This study demonstrates the immediate influence of population expansion on land use and land cover changes, (Moein et al., 2018; Subedi et al., 2013). From 1991 and 2021, the area covered by waterbodies in Jodhpur city increased slightly from 1.31 km (0.6%) to 1.6 km (0.73%). The overall change reveals an increase of 0.29 km, accounting for a 0.13% increase in the total land area of the city (Table-1).

This continuous growth, despite slight changes, shows efficient water management strategies, such as the building or restoration of water bodies to meet urban water demands and environmental conservation efforts. The Surpura Dam project was initiated in 2013 after the then-Congress government received a loan of Rs. 630 crores from the French development agency, (AFD), for the 750-crore project. The enormous Reorganized Jodhpur Water Supply Project created numerous opportunities for the private sector since the project scope included placing new and repairing existing water pipes, establishing new water pumping stations and reservoirs, and installing filtration plants. Currently, it supplies water to many districts of the city, including Mandore, Paota, and Mahamandir. In addition, the dam has the potential to give water to the whole city of Jodhpur for 30 days. (Water Resources Department (WRD), Rajasthan).

Plantation will take place in open places inside the cluster area where no mining activity is underway. Various NGOs and Other organizations working on tree plantation programmes i.e., Jodhpur tree plantation and environment protection committee. The total area of agricultural land experienced a significant increase from 10.51km (4.82% of the total land area) in 1991 to 15.55 km (7.13% of the total land area) in 2021(Table.1). This represents a net growth of 5.04 km, equivalent to a 2.31% rise in the overall agricultural land area. Despite some declines in certain periods, notably between 1991 and 2001, the overall trend indicates a notable expansion in agricultural activities, driven by advancements in irrigation techniques and the implementation of policies promoting agricultural development.

Landuse Landcover Transition between Years (1991-2021)

Table-1, provides a detailed view of the land use and land cover (LULC) class transitions between 1991 and 2021, measured in square kilometres. It tracks how various land use classes have shifted over a 30-year period. Built-up areas experienced significant growth, primarily through conversions from barren land (26.8 km^2) and vegetation (11.62 km^2), (Table-1, Fig. 1). Barren land (147.62 km^2), which was the largest category in 1991, decreased significantly, contributing to the growth of built-up and vegetation classes, (Table-2 and, Fig 1). Water bodies remained relatively stable, with a minor increase. Vegetation saw notable transitions, particularly to built-up (11.62 km^2) and barren land (8.50 km^2); Vegetation was destroyed for the mining activities and then left fellow land. But it remains a significant land use class. Agriculture maintained moderate stability but saw some reduction, mainly transitioning into built-up and vegetation areas. Mining areas expanded slightly, primarily at the expense of barren land. Overall, the data highlights dynamic land use changes driven by urbanization, with implications for environmental management, urban planning, and sustainable development. In summary, the most significant changes occurred in the built-up and barren land classes, while water bodies remained stable. Table-1 presents a matrix of LULC class transitions over 30 years from 1991 to 2021. Key insights include water bodies maintaining stability with minimal change, built-up areas experiencing significant growth, particularly from Barren Land and Vegetation, reflecting urban expansion, Table-1: Landuse and Landcover Changes in Jodhpur City (1991 to 2021)

LULC Classes	Years							
	1991		2001		2011		2021	
	Area (In km²)	%	Area (In km²)	%	Area (In km²)	%	Area (In km²)	%
Waterbodies	1.31	0.6	1.29	0.59	1.36	0.62	1.6	0.73
Built-Up	13.42	6.16	29.96	13.74	47	21.55	54.49	24.99
Vegetation	40.56	18.6	30.9	14.17	44.74	20.52	43.59	19.99
Agriculture	10.51	4.82	8.65	3.97	16.73	7.67	15.55	7.13
Barren Land	147.62	67.7	140.64	64.49	104.06	47.72	97.57	44.74
Mining Area	4.64	2.13	6.62	3.03	4.17	1.91	5.25	2.41
Grand Total	218.06	100	218.06	100	218.06	100	218.06	100
	Overall Change							
Class	1991-2001		2001-2011		2011-2021		1991-2021	
	Area (In km²)	%	Area (In km²)	%	Area (In km²)	%	Area (In km²)	%
Waterbodies	-0.02	-0.01	0.07	0.03	0.24	0.11	0.29	0.13
Built-Up	16.54	7.58	17.04	7.81	7.49	3.44	41.07	18.83
Vegetation	-9.66	-4.43	13.84	6.35	-1.15	-0.53	3.03	1.39
Agriculture	-1.86	-0.85	8.08	3.7	-1.18	-0.54	5.04	2.31
Barren Land	-6.98	-3.21	-36.58	-16.77	-6.49	-2.98	-50.05	-22.96
Mining Area	1.98	0.9	-2.45	-1.12	1.08	0.5	0.61	0.28

Source: Authors

and vegetation transitioning to other classes, particularly built-up and Barren Land (Tabl-1). Agriculture experienced moderate stability with some loss to Built-Up and Vegetation. At the same time, Barren Land was the major source for other classes, remaining the largest category but significantly reduced (Fig. 1). Mining areas saw a small but noticeable increase in area, mostly derived from Barren Land, expanding to 5.31 km² in 2021. The transition matrix reveals significant urbanization and land conversion from Barren Land and Vegetation to Built-Up areas, with Barren Land serving as the primary donor. Vegetation also showed substantial transitions but remains a prominent land use class. Confusion matrices were generated for changes in 1991 and 2021 to gain a deeper understanding of the changing LULC types in the city. The presentation of unchanged pixels is done in bold fonts, arranged diagonally. Figure illustrates the mapping of the land cover transition between the 6 land use types. Table-2 includes the corresponding transitional probability. The built-up area has proven to be the most consistent land use type, it can be inferred that the chances of built-up areas transforming into other land-use types are minimal. It's quite reassuring to observe that the forest type has managed to maintain a certain level of stability, which is likely a result of recent plantation initiatives undertaken by the government.

The largest area of conversion came from forests, accounting for 4.25 km^2, followed by bare ground with 0.49 km^2. It shows that the largest transition is between barren land and built-up followed by agricultural land. In the study area, the water bodies are exhibiting an increase of 0.13%, while the built-up area is seeing an 18.83% expansion, primarily driven by the growth of the human population. Over the past 30 years, there has been a 22% reduction in the total area occupied by other land use types like barren land, Agriculture, and scrubland. In contrast, the mining area has experienced a 0.28% rise. The sole discernible factor underlying this development is the direct or indirect increase in the human population and their corresponding needs, (Moein et al., 2018; Subedi et al., 2013). The built-up expands towards the southern and southwest direction, primarily along major roads. It also extends in a north and northeasterly direction along the roadways that connect the Thar Desert with the rest of the country (Fig. 2 and Table-2). The findings are indicative of the prevailing urbanization trend and government policies. Similar to other studies conducted in emerging nations, this one predicts that urban construction will gradually or quickly encroach over other significant land types, including scrubland and agriculture,(Bewket, 2009; Borana & Yadav, 2017a; Ram & Sheikh, 2023; Rao & Anantha, 2006). In order to prevent irreparable

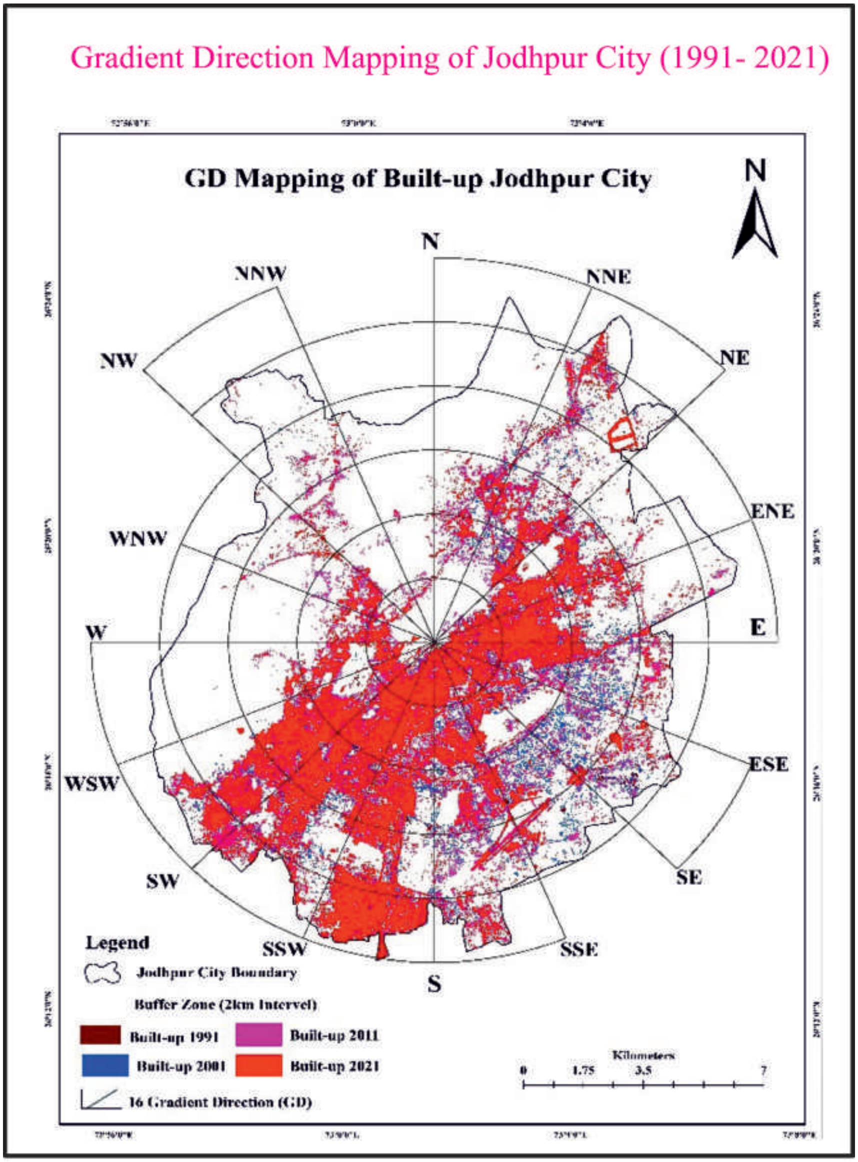
Gradient Direction Mapping of Jodhpur City (1991- 2021)
GD Mapping of Built-up Jodhpur City
N
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
Legend
Jodhpur City Boundary
Buffer Zone (2km Intervel)
Built-up 1991
Built-up 2001
Built-up 2011
Built-up 2021
16 Gradient Direction (GD)
Kilometers
0 1.75 3.5 7

Fig. 2

Table. 2: Landuse Class Transition Matrix (1991 to 2021)

		LULC Class 2021 (Area in Km²)						
LULC Class 2021		Water Bodies	Built-Up	Vegetation cover	Agriculture land	Barren Land	Mining Area	Grand Total
LULC Class 1991(Area in Km²)	Water Bodies	0.89	0.05	0.11	0	0.25	0.00	1.31
	Built-Up	0.01	12.37	1.02	0.02	0.00	0.00	13.42
	Vegetation cover	0.14	11.62	16.81	3.27	8.50	0.21	40.56
	Agriculture land	0.07	1.81	3.47	3.34	1.82	0.00	10.51
	Barren Land	0.49	26.04	22.68	9.56	86.80	2.05	147.62
	Mining Area	0.00	0.19	0.05	0.00	1.34	3.04	4.64
	Grand Total	1.60	52.09	44.15	16.19	98.72	5.31	218.06

Source: Authors

issues affecting other cities worldwide, Jodhpur City must immediately shift from its current commercial model to embrace a sustainable environment-based model of urban development. (Wang et al., 2021b). Numerous residential colonies have emerged along Chopasni Road, which runs in a north-northwest direction from the city, as noted by (Bothale & Sharma, 2007). Currently, the area is experiencing two types of growth. In the northeast, it is characterised by ribbon sprawl, while in the south and southwest, it is a combination of ribbon development and leapfrog development. The primary factor of land use alteration is the joint impact of population growth and rural-to-urban immigration.(Sangaradasse & Eswari, 2019).

Conclusion

The study of land use and land cover (LULC) in Jodhpur City from 1991 to 2021 reveals significant changes driven by urbanization. The most notable trend is the expansion of built-up areas, particularly after 2011, which has resulted in the decline of agricultural and vegetative regions. This transformation has been primarily influenced by population growth, rural-to-urban migration, and the development of new industrial zones on the outskirts. There has been significant urban expansion in the south and south-west direction, particularly along Chupasni Road. The area is currently seeing a mixture of ribbon spiral in the northeast and ribbon and leapfrog growth in the south and southwest. Population growth and rural-to-urban migration are major drivers of land use change. Urban expansion in the northwest is limited by hills and mining areas. Most economic activity is concentrated within the ancient walled city, with no room for further expansion. This study highlights the importance of establishing policies for sustainable urban development in Jodhpur. Authorities should prioritize appropriate land allocation while protecting vulnerable areas from unauthorized development. Regular review of physical projects at all levels of government in Rajasthan is critical to ensure timely access of land for development. Future infrastructure planning should include expansion of the road network and distribution of critical services. Prioritizing the management of urban sprawl and protection of agricultural areas is critical to achieving sustainable development.

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STRATEGIC ACTION PLAN IN LIFT IRRIGATION SCHEMES OF HAVERI DISTRICT, KARNATAKA

Dr. Prakash B. Holer and Dr. V.S. Dhanenavar

Abstract

Charting the evolution of irrigation in Karnataka, this article looks into the nature of shifts that have occurred over the years, and the major challenges it faces now. Under the various Irrigation projects in Karnataka villages have been submerged and work of rehabilitation is completed and shifted to Rehabilitation center. All the works including raising main, intake canal is yet to be complete / completed. The scheme will be implemented by Ministry of Agriculture, Water Resources and Rural Development. Ministry of Rural Development is to mainly undertake rain water conservation, construction of farm pond, water harvesting structures, small check dams and contour banding etc. MoWR, RD&GR, is to undertake various measures for creation of assured irrigation source, construction of diversion canals, field channels, water diversion/lift irrigation, including development of water distribution systems. The programme will be supervised and monitored by an Inter-Ministerial National Steering Committee (NSC) will be constituted under the Chairmanship of Prime Minister with Union Ministers from concerned Ministries. A National Executive Committee(NEC) constituted under the Chairmanship of Vice Chairman, NITIA ayoga to oversee programme implementation, allocation of resources, inter-ministerial coordination, monitoring &performance assessment, addressing administrative issues etc Programme architecture of PMKSY will be to adopt a 'decentralized State level planning and projectile execution' structure that will allow States to draw up their own irrigation development plans based on District Irrigation Plan (DIP) and State Irrigation Plan (SIP). It will be operative as convergence platform for all water sector activities including drinking water & sanitation, MGNREGA, application of science & technology etc. Through comprehensive plan. State Level Sanctioning Committee (SLSC) chaired by the Chief Secretary of the State with the authority to oversee its implementation and sanction of projects.

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Introduction

Since 1973 Karnataka has been initiating, implementing and modifying several socio- economic policies to upliftment of the weaker section of the society with special focuson rural areas. Union Government of India is also supporting the state government in this endeavor in terms of financial support grant-in-aid. Nonetheless, among 30 states of India, Karnataka state is most elevated developed one with a average GSDP (Gross State Domestic Product) improvement of 8.2 percent in the financial year 2010-2011. The slanted circulation of land possessions in Karnataka for the year 1955-56 and the year 1980-81 is very notable, the farmers' allocation with respect to land was that 30.8percent of farmers involved 75.1 percent of the land and 19.6 percent of farmers involved 58.7 percent of the land respectively. Fundamentally, small and marginal landholders were expanded from 11.64 lakhs to 25.46 lakhs (more than two-fold) and from 47.3 percent to 59.1 percent in a similar period (1955-56 to 1980-81). Likewise, the zone of Small and Marginal Farmers (SMFs) has expanded from 11.19 lakh hectors (10.3%) to 22.76 lakh hectors (19.4%) about twofold. Subsequently, enhancements in agronomic practices ought to be coordinated towards Small and marginal farmers. The major objective of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal waste water for peri-urban agriculture and attract greater private investment in precision irrigation system.

Objectives

(1) To know the lift irrigations in Haveri district.
(2) To improving water management of the lift irrigation in Haveri district
(3) To enhance the provisioning services and of the ecosystem in lift irrigation schemes of Karnataka

Study Region

Haveri district is situated in the western part of the central Karnataka state. The district encompasses an area 485156 hectares. In its shape the district may be regarded as roughly resembling an inverted square shape as per Peter Hagget's method shape index. Its greatest length from north to south is about 111 kms and its great growth from east to west is about 87 km. The district is bounded on the North by the districts of Dharwad and Gadag; on the south by the district of Davanagere and Shimoga and the west by the district of North Kanara. All these districts which surround Haveri belong to Karnataka state itself. Varada river act as the central part of the district and it flows west to east direction about 128 kms on the north-east and south, the Tungabhadra River flows in between Haveri-Gadag, Shimoga, Davanagere and Bellary districts.

Database and Methodology

The study was used descriptive and analytical research methods to analyze the taken objective. To understand the role of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) towards beneficiary's lives style, it has used telephone survey to gather the opinion from few beneficiaries. Majorly secondary data source too used by the work of many researchers who have done their research on the same issue. The government statistical reports, websites, journals and books have referred for the better perception about the scheme performance towards beneficiaries' socio-economic conditions.

Results and Discussion

Irrigation based Classification

In the district gross irrigated area is 159715 ha and the net irrigated area is 137337 ha. The total rain fed area in the district isaround163145 ha. Ranebennur taluka having 31 % area under irrigation stands first whereas very minimum area i.e. 3.3 % is in Savanur taluka. Around 61564 ha are under protective irrigation covered by bore wells. If Major irrigation Projects are completed, additional area of 78140 ha. Will be brought under irrigation and through implementation of Minor Irrigation projects, additional area of 28682 ha. will be brought under irrigation which increases percentage of area under irrigation from 38.15 to 67.80.

Agro-ecology, Climate, Hydrology and Topography

The district has the total geographical area of 4,85,156 ha, with cultivable area of 3,62,046 ha which makes 74 % of total area. The area under forest isabout9 % (47,454 ha), area not available for cultivation is 8 % (39,100 ha), while fallow land is 4.0 % (19068 ha). Average rainfall of the district is 792.7 mm and an average of 60 rainy days. The agro climatic zone-8 (Northern Transitional zone) comprises of around 65% of red soil area with normal annual rainfall of 747.6 mm, covering 6 talukas namely Haveri, Byadgi, Hirekerur, Ranebennur, Savanur and Shiggaon.

The Hangal taluka comes under zone-9 (Hilly zone) with annual rainfall of 1063 mm. The rainfall pattern of the district is bimodal (July/August & Sept/Oct) which facilitates to take up crops in kharif and Rabi seasons. Around 37.02% of area is under irrigation (Table-1).

Table-1: Irrigation Based Classification

Sr. No.	Blocks	Irrigated (Areainha)		Rainfed (Areainha)	
		Gross Irrigated Area	Net Irrigated Area	Partially Irrigated/ Protective Irrigation	Un-Irrigated or Totally Rain fed
1	Shiggaon	8264	6900.21	3665	31637
2	Savanur	5731	4534.25	2007	41944
3	Hangal	34921	29664.99	10141	10691
4	Haveri	19330	15324.69	12313	36251
5	Byadagi	14028	13219.02	7786	12230
6	Hirekerur	29627	25061.46	10244	24103
7	Ranebennur	47814	42632.78	15408	6289
	Total	159715	137337.4	61564	163145

Source: Authors

Analysis of Lift Irrigation Schemes of Haveri District

Shiggaon Lift Irrigation Scheme: The scheme is proposed to irrigate 9900 ha by sprinkler and 3600 ha by drip irrigation & provide drinking water facility to Shiggaon, Savanur and Hanagal taluks of Haveri district. Sprinkler irrigation system has been adopted to irrigate 9900 ha area and the works are completed (Fig. 1). The project has been dedicated to the nation. Further, the scheme of filling 18 tanks under this project is completed and the scheme of filling 39 tanks is under progress. Project start date 15-Aug-2009 and Project completion date 31-Mar-2025.

Savanur Lift Irrigation Scheme: Savanur lift irrigation scheme is proposed to irrigate 15500 ha of area in 30 villages of Savanur taluk and also filling of 09 tanks by lifting 1.5 TMC of water from Varada River near Kalasuru village of Savanur Taluk. The works of filling 48 MI tanks are under progress & head works are nearing completion (Fig. 1 and Table-2).

Basapura Lift Irrigation Scheme: Under this project it is proposed to lift 0.6 tmc of water in two stages from the right bank of Varada River near Basapura village

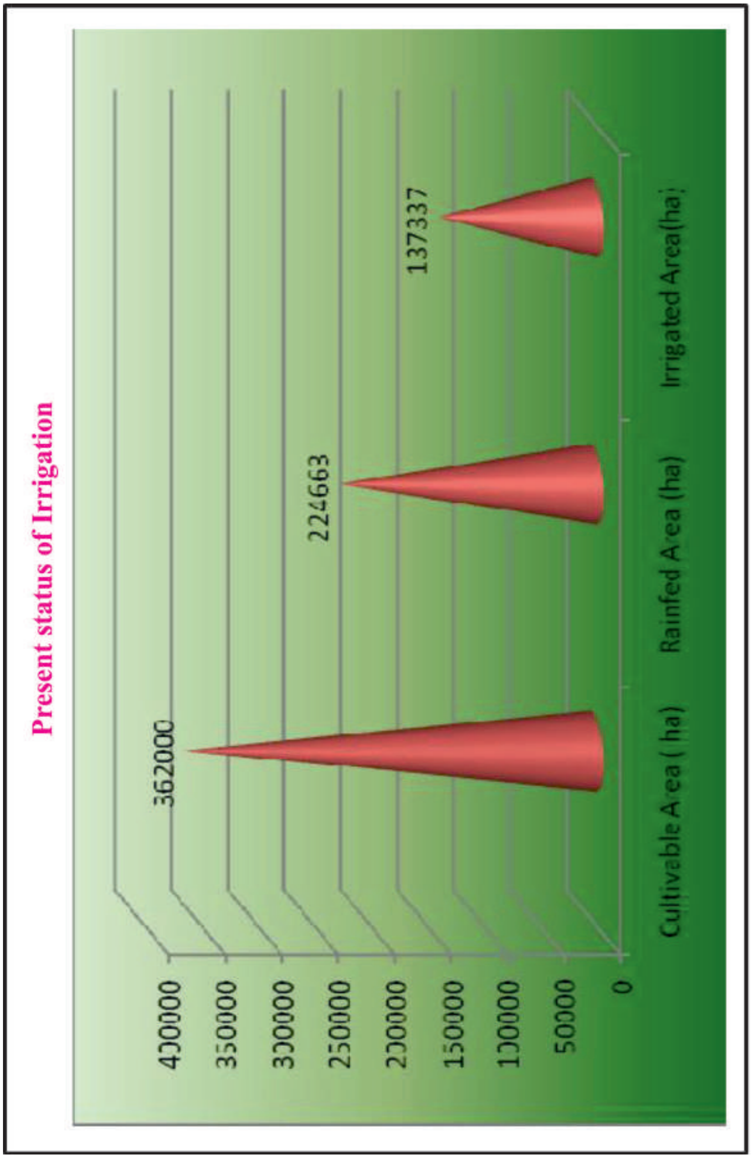
Present status of Irrigation
400000
350000
300000
250000
200000
150000
100000
50000
0
362000
224663
137337
Cultivable Area (ha)
Rainfed Area (ha)
Irrigated Area(ha)

Fig. 1

Table-2: Agro-ecology, Climate, Hydrology and Topography

S. No.	Block	Block Area (ha)	Normal Annual Rainfall (mm)	Average Monthly Rain fall (mm)	No of Rainy Days (No)	Maximumm Rainfall Intensity (mm)	Potential Evapor-Transpiration (PET)				Elevation		
							Period			Cumulative Total	Min.	Max.	Mean
						Upto15 Min	Summer	Winter	Rainy Season				
1	Shiggaon	58920	837	67.23	65	86	497.749	367.19	712.85	1577.8	449	653	551
2	Savanur	53901	706	58.86	54	88	478.2	348.3	664.9	1491.4	431	595	513
3	Hangal	77525	1063	84.36	74	83	466.1	396.4	672.3	1534.8	436	606	521
4	Haveri	79985	781	62.24	59	83	486	367.4	688.8	1542.2	411	584	497.5
5	Byadagi	43656	692	58.34	58	76	487.2	354.3	688.5	1530	466	672	569
6	Hirekerur	80694	856	69.94	65	79	463.071	346.21	626.53	1435.8	442	793	617.5
7	Ranebennur	90475	614	52.00	45	82	465.747	349.71	638.54	1454	421	623	522
	Total	485156	792.7	64.7	60	82	478	361	670	1509	437	647	542

Source: Authors

to irrigate 2000 ha of area in 13 villages of Hangal Taluk of Haveri District. Both the stages of works are completed and 2000 ha of area is brought under irrigation.

Kachavi Tank Filling Scheme: Kachavi TFS is proposed near village Kachavi in Soraba Taluk of Shivamogga district by lifting 0.15TMC of water from Varada River to augment scarcity of water in 11 villages by feeding 21 tanks in these villages. The DPR of the project is administratively approved for Rs.16.50 crores and at present, the works are under progress.

Dharma Modernization: Dharma Dam was constructed across Dharma River near Yemgalli village, Mundagod Taluka, Uttara Kannada District in 1994. Irrigation is being provided to about 7692 Ha land. The project has already been completed and modernization works have been taken up. The works are completed.

Development of Kanaka Sarovara (Doddakere) in Kaginele village: The Kanaka Sarovara (Doddakere) in Kaginele village is spread over an area of about 280 acres it is believed that the saint poet Kanakadasa used to worship Sri Adikeshava after taking a dip in this lake and it is envisaged to develop the tank in a comprehensive manner, accordingly it is proposed to develop the tank bund, construct an island, a park, musical fountain, pathway and to provide other facilities. The DPR of the project is administratively approved for Rs.14.15 crores and at present, the works are under progress.

Filling of Durgadevi and Bahugrama tanks of Hirekerur town by lifting Kumadwathi water from Madaga Masuru tank at Hirekerur taluk, Haveri district: This project envisages filling 8 tanks of Durgadevi and adjoining tanks in the town of Hirekerur to 50% of their capacity by lifting 0.067 TMC of water from the river Kumadvathi by constructing a Jack well and Pump house at Thippayikoppa village of Hirekerur taluk. The DPR of the project is administratively approved for Rs.140.00 crores in Oct-2017 and at present, the works are under progress.

Madluru Tank Filling Scheme: This project envisages filling 13 tanks of Hirekerur taluk and 2 tanks of Byadagi taluk in Haveri district to 50% of their capacity by lifting water from the river Varada by constructing a Jack well and Pump-house at the upper part of Honkana barrage near Thiluvalli village of Hanagal taluk. The DPR of the project is administratively approved for Rs.38.00 crores in Oct-2017 and at present, the works are under progress.

Guddada Madapura Tank Filling Scheme: This project is envisaged to fill 13 tanks in Hirekerur taluk of Haveri district by lifting 0.037 tmc of water from

Tungabhadra River. The DPR of the project is administratively approved for Rs.23.00 crores in Feb-2018 and at present, the works are under progress.

Filling of 17 tanks in Asundi and adjoining areas: Asundi LIS is intended to lift water from Kumadwathi River to fill Asundi and 17 surrounding tanks of Ranebennur, Byadagi and Hirekerur taluk in Haveri district. The DPR of the project is administratively approved for Rs.79.80 crores in Dec-2017 and at present, the works are under progress.

Anur Tank Filling Scheme: Due to reduction in inflow to the tanks in Byadagi taluk, Haveri district over the years there is a severe stress for drinking water in the area. In view of this the project is taken up to solve the drinking water problem of the area by filling these tanks to 50% of their storage capacity and also assist in ground water recharge. Under this project, it is proposed to lift 0.50 tmc of water from Tungabhadra River near Choudanapura village and fill 30 tanks of 18 villages in Byadagi taluk. The DPR of the project is administratively approved for Rs.212.00 crores in Oct-2019 and at present, the works are under progress.

Budappanahalli Tank Filling Scheme: Due to reduction in inflow to the tanks in Byadagi taluk, Haveri district over the years there is a severe stress for drinking water in the area. In view of this the project is taken up to solve the drinking water problem of the area by filling these tanks to 50% of their storage capacity and also assist in ground water recharge. Under this project, it is proposed to lift 0.30 tmc of water from Tungabhadra River near Kotihal village and fill 17 tanks in Byadagi taluk. The DPR of the project is administratively approved for Rs.157.00 crores in Oct-2019 and at present, the works are under progress.

Balambeed Tank Filling Scheme: Due to reduction in inflow to the tanks in Hanagal taluk, Haveri district over the years there is a severe stress for drinking water in the area. In view of this the project is taken up to solve the drinking water problem of the area by filling these tanks to 50% of their storage capacity and also assist in ground water recharge. Under this project, it is proposed to lift water from Varada River and fill 162 tanks in Hanagal taluk. The DPR of the project is administratively approved for Rs.386.55 crores in Oct-2019 and at present, the works are under progress.

Upper Tunga Project: The project started during 2000-01 and total length of canal is 270 km. It provides an annual irrigation of73239 ha of land by utilizing 12.24 TMC of water from Tunga Dam near Gajanur village in Shimoga district. The Dam is situated at Latitude: 13°-50’30” Longitude: 75°-31’-0”. Totally 220 villages will be benefited from this project main canal runs to a length of 270 Km & finally the main canal lead off to Devagiri tank in Haveri taluk. So far Rs.1307.40 Crores expenditure has been incurred. This project aims to cover73239.00ha of area in the Haveri district. This project covers 30530 ha in Ranebennur, 27908 ha in Haveri, 9468 ha in Hirekerur, 3175 ha in Byadgi and 2158 ha in Hangal taluka. Up to March-2016, 22724 ha irrigation potential created in Ranebennur taluka and 9468 ha irrigation potential in Hirekerur taluk. Action plan of Rs.550.47 Crores has been submitted by the Major Irrigation Department to cover remaining area of 41047 ha. Out of which 8570 ha area is further covered by micro irrigation system and for this action plan of Rs.450 crores have been submitted.

Tiluvalli Lift Irrigation Scheme: The Tiluvalli Lift Irrigation Scheme is proposed to irrigate 2,500 Acres (1012Ha) using 0.76 TMC of water from Varadha river. The Scheme is comprised of creating Irrigation potential in two stages. The First Phase is Lift irrigation works & 2nd Phase is Canal &Tank Rejuvenation work. The project is situated at Latitude: 17O 12′ 45″and Longitude: 14°38′50″. Totally 03 villages of Hangal Taluk in Haveri District will be benefited from this project. So far Rs. 19.16 Crores expenditure has been incurred. To bring an area of 1012 ha under irrigation, action plan of Rs. 55.56 crores have been submitted. Water allocation is 0.76 TMC (.26 TMC from Krishna basin and .50 TMC from Godavari basin).

Itagi - Sasalwad Lift Irrigation Scheme: The Itagi-sasalwada lift irrigation scheme envisages lifting of 1.5 cu mecs of water from left bank of Tungabhadra River near Itagi village to irrigate 1983.00 ha of lands coming in 11 villages of Shirahatti and Mundargi taluk in Gadag district and one village in Haveri taluk in Haveri district. The Jack well cum Pump house is situated at Latitude: 14°57'8"NLongitude: 75°43'27"E". The project covers 65.27 ha of area in Teredahalli village of haveri district and the project has been completed.

Guddadamallapur Lift Irrigation Scheme: The Guddada Mallapur Lift Irrigation Scheme is proposed to irrigate 13,000 Acres (5261 Ha) using 1.00 TMC of water from Varadha river. The Scheme is comprised of creating Irrigation potential in two stages. The Jack well cum Pump house of Fist Stage is situated at Latitude: 14o39′22"NLongitude: 75o13′01"E". Totally 22 villages of Byadagi Taluk in Haveri District will be benefited from this project. So far 3800 ha area has been brought under irrigation. To cover the remaining area of 1461 ha action plan of Rs.8.11 crores has been submitted. A total of 1 TMC has been allocated for this project.

Acchikere Tank Filling: Source of water lifting from Dharma River near Kallakala barrage, Raising main length 825 m of HDPEPN 8.0 of 260mm dia, type of Pump – Submercible pump. Due to Scanty rainfall in the catchment area in the past years and also due to development activities in the upstream catchment these tanks are not receiving the desired quantum of water for filling these tanks. The villagers mainly dependent on these tanks for drinking water and other purposes. In view of above requirements, it is proposed to take up the scheme of lifting water from Natural nala. The proposal of filling Acchikere tank filling tank will be benefit the area by ground water recharge and will become part of watershed development plan. For this action plan of Rs.315 lakhs have been submitted.

Karur Tank: Filling of Karur tank coming in Ranebennur Taluk Haveri District by lifting water from Natural Nala crossing @ 36 Km of Dy-2 canal of UTP under UTP-SCP programme for the year – 2015-16. Due to Scanty rainfall in the catchment area in the past years and also due to development activities in the upstream catchment these tanks are not receiving the desired quantum of water for filling these tanks. The villagers mainly dependent on these tanks for drinking water and other purposes. In view of above requirements it is proposed to take up the scheme of lifting water from Natural nala. Due to Scanty rainfall in the catchment area in the past years and also due to development activities in the upstream catchment these tanks are not receiving the desired quantum of water for filling these tanks. The villagers mainly dependent on these tanks for drinking water and other purposes. In view of above requirements, it is proposed to take up the scheme of lifting water from Natural nala. The proposal of filling Karur tank will be benefit the area by ground water recharge and will become part of watershed development plan. For this project Rs.89.20 Lakhs has been estimated. Shiramapura tank 1, 2 & 3, Belagalapete 1 and tanks filling: Source of water lifting from Dharma River near Shiramapura barrage, Raising main length 3360m of HDPE 80 PN 8.0 of 355mm dia, type of Pump – Submercible pump. Due to Scanty rainfall in the catchment area in the past years and also due to development activities in the upstream catchment these tanks are not receiving the desired quantum of water for filling these tanks. The villagers mainly dependent on these tanks for drinking water and other purposes. In view of above requirements, it is proposed to take up the scheme of lifting water from Natural nala. The proposal of filling Shiramapuratank 1, 2 & 3, Belagalapete 1&2 tanks filling will be benefit thereby ground water recharge and will become part of watershed development plan. For this action plan of Rs.439.0 lakhs have been submitted.

Conclusion

Haveri district is located in middle part of Karnataka. West part of Byadgi, and south part of Hanagal in Haveri District is hilly terrain and higher elevated areas. These are not covered under any major irrigation projects. The average annual rainfall is less than 647mm and unevenly spreads in the rainy year. The water retaining structure in the district (MI/ZP Tanks) are not filled since from 10-12 rainy years due to scanty and uneven rain fall. The minor irrigation and Zilla Panchayat tanks are built to serve the need of drinking water requirement of the rural population, the proposed MI/ZP tanks are located at North part of Hanagal, in Haveri district. These villages are located towards north of Varada River. The above villages are located at upstream side of the command area of the Dharma project. The flow of water in Varada River is almost 4-5 months of the year, hence the detailed survey is carried out for filling of MI / ZP tanks in Balambeedu, Hangal and Belgalpet and Hanagal taluks of Haveri District. The flow data shows that flow in the river is sufficient to take the project for filling 50% of the tank capacity with 25% of evaporation losses. The gauged flow of Varada River at Hosaritti gauging point confirms that required quantity of water is available for lifting during monsoon.

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AN ATTEMPT FOR SUSTAINABLE REGIONAL PLANNING IN SOMPURA BENGALURU RURAL DISTRICT, KARNATAKA

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Abstract

A region is a concept in geography which deals with certain homogeneous factors, maintaining its uniqueness as compared to those in the neighborhood, in the recent times, when climate change and environmental conservation have become the most talked about components, the region-based study should focus on sustainability as well. Sustainable urban Development, the term may appear unachievable and more conceptual than real but efforts should be taken to initiate such targets. Since cities and urban areas are the engines of growth especially in Asian countries it is crucial to promote thoughtful strategies for urban planning in the core city and the country-sides. Sompura is situated in the close vicinity of Bengaluru city, precisely in the adjoining district called Bengaluru rural has quite an influence of the city itself, nonetheless, it maintains its uniqueness in various characteristics as sustainable methods of regional level planning has been thoroughly implemented. As the paper proceeds, it would be also known that Sompura has a well-equipped industrial area that promotes various industrial set up while keeping the environmental conservation attempt the top most priority. Sompura, is a sub-region in the Nelamangala Taluk of Bengaluru Rural District of Karnataka has distinctively introduced planning measures in the most sustainable ways. Since it is situated at close proximity of Bengaluru city, it surely has to share the load of the previous one's urban sprawl but surely uses its sustainable techniques of maintaining regional balance. This balance is not the economic one, rather it is the growth of industries and the environmental sustainability. Firstly, Sompura it would cater to the growing needs of Bengaluru city like housing the excess population while making provisions for new industrial units. Secondly, it has the challenging task of maintaining what it already has, for instance its farmlands and lakes replenishing land use features. As the Sustainable Development Goals calls for inclusive and resilient cities, their adjoining regions should also be developed accordingly, with thoughtful use of vacant land, using open areas for conservation efforts and paving ways for new industries too.

Introduction

Shrinking agricultural land, wetlands, and green patches are faster in peripheral region of Bengaluru city and it is quite given that unplanned growth is taking place here quite rigorously (Verma S., Chatterjee A., 2017) in this area. The land use components like, natural ponds and garden areas are always susceptible to the common threat towards disappearance in the peri-urban interfaces (Colding, 2013) (D'Souza, 2013). This paper highlights the case of Sompura in this context where suitable planning measures have been adopted to analyse its industrial growth in the backdrop of environment conservation. Post-independence growth in Bengaluru was clearly driven by the industrial mode of development. Since the 1990s, much of the city's spatial expansion has been in the southern direction and was clearly driven by the industrial mode of development. Generally, growing cities in number and area today talks about taking measures to reduce carbon footprint, accommodating the migrants coming across state and districts while protecting the existing bio-diversities in-side the city and beyond its limits into the fringe areas (Wittwer S., Hofer K., 2023). Likewise, Sompura being the fringe area of Bengaluru city takes up the biggest challenge of economic growth and environment sustainability. The paper would act as a ready reference where fringe area of an Asian city has been urbanized with upcoming industrial firms and transport activities without hampering the very nature of the region with lakes being one of them. Here the framework of planning consisted of several measures of wholesome planning at sustainable level. Though the planned activities include maximum coverage under industrial activities, followed by transportation activities. It has quite a considerable portion of land marked under park and playground facilities and as buffer for non-commercial or conservation activities. The provision for housing activities is kept minimum to suffice the need of open areas.

Study Region

As already discussed, Sompura is situated in the vicinity of Bengaluru city within the district of Bengaluru Rural. Before going into details, one should know that Karnataka is one of the southern most states of Indian Peninsula, which geographically is a plateau region outlined by parts of Sahyadri in the west lined by the coastal areas, also named Karavalli. At present it has thirty-one districts, managed, by four Administrative Divisions, namely, Bengaluru Division, Belgaum Division, Kalaburagi Division and Mysuru Division. Devanahalli, Doddaballapura, Hoskote and Nelamangala are the four sub-divisions of Bengaluru Division. The area of study is Sompura, which is situated in the north-western part of Bengaluru city, forms one of the sub-regions or Hobli of Nelamangala has been marked with great potential ties as per government reports of Karnataka for industrial development. With such potentialities, the region of Sompura has attracted the city planners and industrial ventures for future expansion and development. It presently includes sixteen village groups which may be brought under urban and industrial planning strategies keeping in mind the issue of environment sustainability. The village circles also called village groups include more than one village which specifically include marked areas in Laxmanapura, Nidavanda, Pemmanahalli, Bharathipura Village of Sompura Hobli, by the Karnataka Industrial Area Development Board. The village groups altogether have seventy-one villages of which forty-seven villages have less population concentration than the average, whereas the remaining twenty-four villages have slightly more than average concentration of population.

Objectives

There are concisely two major objectives of the study. Firstly, the paper compares the demographic components of villages in Sompura for understanding various levels of the disparities and levels of development. The second objective is to highlight the planning proposals of making Sompura a new potential area of industrial development with major parameters of land use change and government proposals.

Database and Methodology

The study in this paper has been conducted in three phases. The initial or the first phase included studying and going through various past literatures as related to the urban fringe areas especially in the Asian countries. It was necessary to understand the process of urbanization that take place in regions where population growth remained high. In this regard, Asian cities and the reports posted online and journals based on various case studies were studied intensively. Infact, how these urban areas tackle the growth and over spillage of urban population remained an interesting guide to study the present topic. For that matter, inter-city cases in Mumbai, Kolkata, Delhi and Chennai there remain always a struggle to accommodate the growing population which are often tackled through the fringe area development proposals. Sompura, being in the close proximity of Bengaluru city, known for its software industries has been the fringe area where the government are planning to shift some industries while growing new, for managing the pressure. The first phase included also the collection of demographic data on population, gender distribution, working status, literacy profile from the Census Office which were used in the later phases.

The second phase commenced with the accumulation and categorization of the available data which were mostly demographic and land use related with special emphasis on the upcoming industrial units and firms. The study region has great potentialities in industries and also had quite a considerable population still practicing agriculture that needed to be highlighted for future references. The final phase comprised of the in-depth analysis of the gathered numerical data with various statistical tools and measures highlighting the planning for Sompura in a sustainable way. Infact, it also included the focus on land use map that distinctly, kept the balanced development and sustainable on various parameters of urban growth.

Result and Discussion

Before going into the details study and analysis of the study, the village groups should be introduced by names. As mentioned, there are sixteen village groups which include seventy-one villages that have been chosen for sustainable urban and industrial growth. The village groups are namely, Sompura (5 villages), Lakkuru (3 villages), Agalakuppe (5 villages), Devarahosahalli (3 villages), Nidavanda (4 villages), Baragoor (6 villages), Heggunda (1 village), Elekyatanhalli (6 villages), Nasserapura (6 villages), Maralakunte (3 villages), Shivagange (3 villages), Baragenahalli (6 villages), Kambal (6 villages), Billanakote (4 villages), Honnenahalli (4 villages) and Karekattiganuru (8 villages). All these villages are brought under Sompura Planning Area for promoting sustainable urban growth amidst industrial venture. It is always important to discuss the population and social groups of these villages including other demographic parameters for understanding the present situations. The maximum concentration of population is found in Sompura village-group followed by Agalakuppe and Elekyatanhalli. The least population is found in the village group named Heggunda, Devarahosahalli and Honnenahalli (Census of India, 2011). As discussed earlier, the villages mostly are marked with less than average concentration of population; this may attribute to the growing out-migration of the dwellers to the city core of Bengaluru for employment opportunities. Typically, as seen in most Asian regions, Sompura also shows male dominance of population over that of the females; though village groups, namely, Maralakunte and Shivagange exhibit female dominance over the males. In literacy, majority of the villages exhibit moderate literacy, between 60-80%; out of 71 villages 56 villages fall in this category. There are 4 villages where literacy is low, ranging between 50-60% (Fig. 1). There are only 11 villages where literacy percent is over 80; of which Kengal Kempohalli of Billanakote village

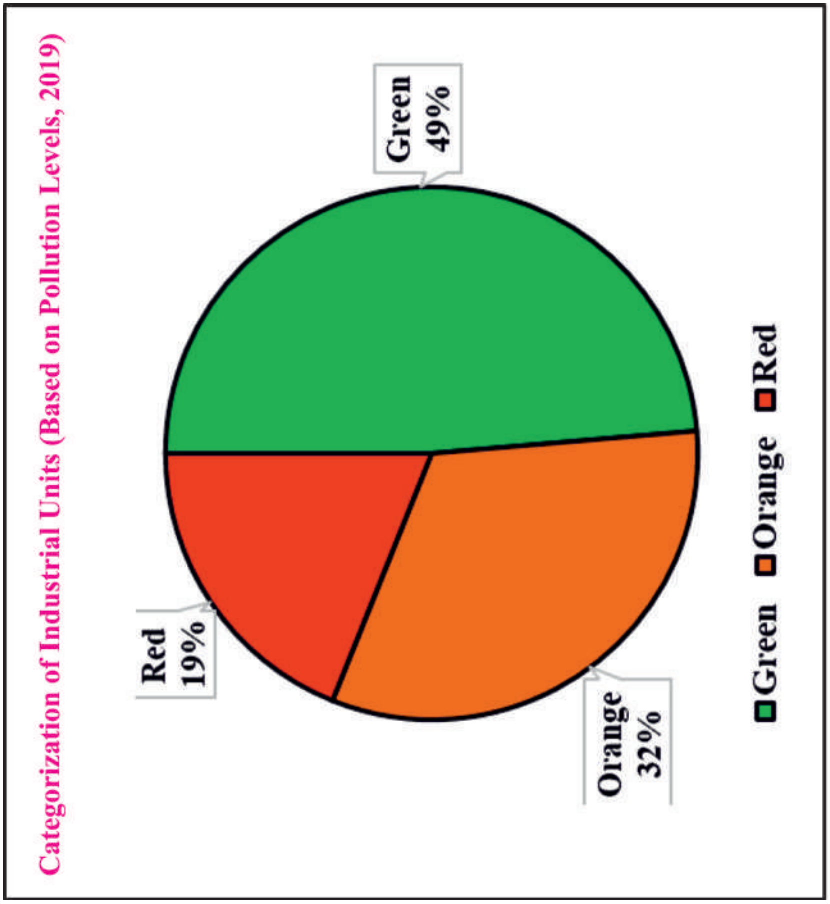
Categorization of Industrial Units (Based on Pollution Levels, 2019)
Green 49%
Orange 32%
Red 19%
Green
Orange
Red

Fig. 1

group tops the list with almost 92% literacy followed by Kengal of Baragenahalli village group, with slightly over 90% literacy rate. The social composition of the villages consists of the Scheduled Caste population which are mostly concentrated in Honnenahalli (Honnenahalli village group) and Kallanayakanahalli village (Agalakuppe village group) followed by Sompura Village (Sompura village group). These statistics of backward population are necessary information for the government policy makers. If the region has been explored for future industrial ventures it is also the responsibility of them to take utmost care of the backward castes of the region and providing them income and training opportunities for reducing the risk of marginalization. On the other hand, as far as the Scheduled Tribe population are concerned, 25 villages out of 71 have nil distribution of Scheduled Tribe population. However, out of 46 villages, Agalakuppe, Lakkuru and Sompura belonging to Agalakuppe, Lakkuru and Sompura village groups respectively show the higher concentration of Scheduled Tribe population. This requires special attention on not only employment, but also basic needs of education, female empowerment and food supply. The villages under the study area dominate population in unreserved category, though the marginal communities demand special attention particularly when we are seeking sustainable and inclusive development. The efforts are needed to upgrade the condition of the tribal and backward population through various techniques on farming activities, skill based learning systems and empowering the women through education and knowledge sharing to be particular. While discussing empowerment of women, the region under study shows a concerning picture on male and female literacy gaps.

There are around five villages, namely, Madaga (Heggunda village group) Basavapatna (Kambal village group), Baragoor, Halluharive (Baragoor village group) and Govindapura (Naraseepura), where the male literacy percent is much higher than that of the females. Of the remaining 66 villages, 23 villages accounted for moderate disparity in the distribution of male and female literacy rates. Of the rest, 38 villages, record lower rates of disparities between male and female literacy rates. Villages, named Sompura, Lakkuru, Gowrapura and Beeragondanahalli have least levels of disparities in male and female literacy rates. If a region is considered for development and sustainable planning, social and economic wellbeing are must and with huge gaps in male and female literacy levels it would not be easy to achieve. As far as the total workers are concerned, numerically, Sompura village houses maximum workers followed by the villages of Heggunda, Lakkuru, Maralukunte and Beeragondanahalli. The villages, namely, Dasanapura, Aladahalli, Madaga Bettadahosahalli and Kallanayakanahalli however record least numbers of working population. Of the total main workers, village Kamalapura records highest male workers with almost 98% working males, but correspondingly, only 2% are the female main workers; the village Hosahalli and Gangenapura record 96% and 92% male workers whereas women participation is as low as 4-8%. On the other hand, the village named, Kuntbommanahalli records lowest male workers (14%) with women workers dominating the work force here. Moreover, as far as the marginal work force is concerned, dominance of women labourers is witnessed in many villages. As far as the Census of India definition goes, a person who works for less than 183 days or six months in a year may be termed as marginal. The women often work seasonally in farms and other agriculture-based activities along with other few works where they earn some money as wages. The villages like, Veerasagara, Madaga and Halenahalli have 100% women participation in marginal activities. On the other hand, Bharateepura, Kasaba Nijagal, Tattekere, Giriyanapalya, Bennageru, Benachanahalli, Gangenapura, Ghantehosahalli, Basavapatna and Dasanapura show 100% male dominance in marginal labour forces. Additionally, it has been noticed that in the study area that more the women are literates less are their participation in the main work force. This is a peculiar case as usually, the women participation in work force is directly proportional to their levels of education. However, such event may be attributed to the reason that once the women become educated, they leave the villages for better employment opportunities outside and seldom participate in the limited employment opportunities available. The villages undertaken for planning are mostly agricultural and few mining activities are found which hardly provide handsome money to the potential work forces (Table-1).

Industries and Firms

As the demographic parameters are already discussed, industrial development would facilitate the overall upgradation of Sompura region. Following is the table-1, which lists the major industrial units that have been planned to be set up in the region over time. These include agricultural products, solar lights, fabrics, steel, chemicals and many others which would provide employment for the people residing in the area of course after training and skill development initiatives. It is imperative to note that industrial activities in Sompura would undoubtedly attract experts and skilled labourers from outside and that would have a holistic impact upon the region. But whether the already settled farmers and marginal labourers would get to experience the ‘good’ of such initiatives would remain a question.

As far as the agro-based industries are concerned, they would excel, but for other activities like wire making and aluminium firms, they need training and knowledge which the government and the private organizations should be aware of.

Table-1: Products and Items Produced in Sompura-Dobbaspet Industrial Area (2008-2021)

Agriculture Product	Packaged Drinking Water
Solar Light fittings	Coffee curing and roasting
Precision Machine components	Aluminium Door & windows
Laminated fabric	Commutators Rotor
Structural Steel	Concrete Blocks & Allied Concrete
Machine tools	Fruits & vegetables, meat, milk products
Educational Institutes	Hazardous waste
Iron Casting	Tablets, Capsules, Ointments & Cream, liquids
Steel Product	Compressed Oxygen and Compressed Medical Oxygen
Solar heating channel	Polypropylene, white net
Solar Heating	Common effluents
Stone Crusher	Bulk drugs
Steel Coils	Telephone towers
Garment stitching	Chemicals

Source: Report (2019): Karnataka Industrial Policy 2014-19 & Report (2019) E-Registration of Industries: Nelamangala

Hazard and Planning

Any kind of activity, where industrial development comes as a reality, it brings with it the fruits of development and upgradation of economy, be it regional or national. But what remains concerning is the hazards and environment quality degradation that have a big role to play on the region's overall land use and off-course human health. Sompura region struggles with such dilemma as well; the government of Karnataka however tackles these issues well along with the Central Pollution Control Board through categorization of industrial units and regular monitoring the same. The permissible industrial sites of Sompura includes three categories as outlined by Central Pollution Control Board; firstly, the Red categorized industries, which are those which mostly are responsible for causing air pollution, whereas the green category form the least pollution causing industrial units. The orange category exhibits industries which are moderate in causing industrial hazard and pollution. Sompura industrial region includes thankfully, the greater percentage of green categorized industrial units; almost 49% firms in Sompura region are under the green category, followed by the orange ones with 32% and least are the red marked industries (19%). This has been considered a sustainable initiative undertaken by the government of Karnataka where industries are set up in a way where environment related hazards could be kept at check.

Categorization of Industrial Units based on Pollution Levels cause (2019)-Sompura Sustainable Landuse

As far as land use planning is concerned, Sompura region has been brought under strict measure of sustainable urban development with thoughtful growth of industries. Sompura, as discussed earlier sets an example to develop as an ideal region promoting sustainable development. Here the framework of planning consisted of several measures of wholesome planning at sustainable level. Though the planned activities include maximum coverage under industrial activities (49%), followed by transportation activities (14%); but quite a considerable portion of land has been kept under park and playground facilities (9%). Land has been kept as buffer for non-commercial or conservation activities (10%) also. The provision for housing activities has been kept minimum at 3% followed by areas under other utilities (Fig. 2).

As the industrial activities grow in any region, there is always a very common practice of changing land use activities to non-agricultural activities with minimum efforts on conservation. However, Sompura remains an exception. Sompura is exceptionally and quite commendably manages and implements the conservation measures including its wetland (GOK, 2019). Accordingly, many measures have been undertaken to maintain the natural wetlands, which are discussed below.

(1) The efforts of conservation of wetlands in Sompura has been already taken by Karnataka Tank Conservation and Development Authority
(2) Environment clearances were obtained from the central Pollution control Board since 2013 for setting up of Industrial Area with few guidelines and measures for conservation

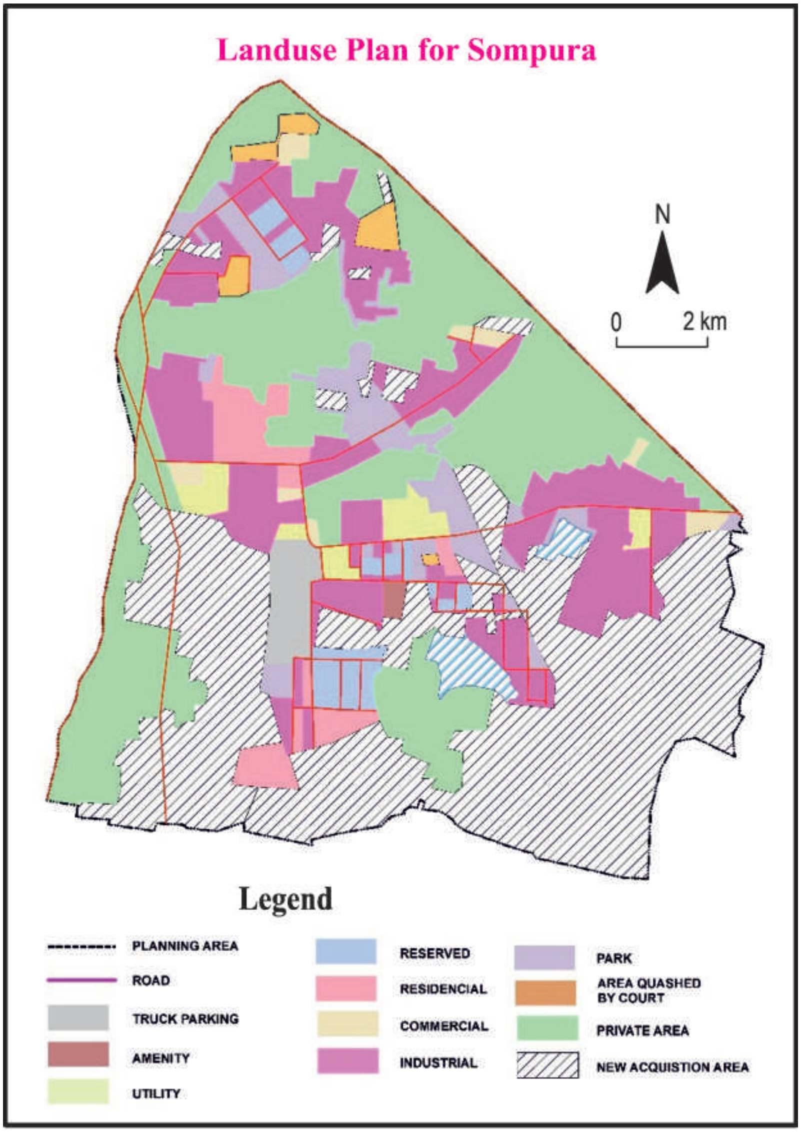
Landuse Plan for Sompura
N
0 2 km
Legend
PLANNING AREA
ROAD
TRUCK PARKING
AMENITY
UTILITY
RESERVED
RESIDENCIAL
COMMERCIAL
INDUSTRIAL
PARK
AREA QUASHED BY COURT
PRIVATE AREA
NEW ACQUISTION AREA

Fig. 2

These conservation measures are as below:

- The Sompura Industrial Area should be associated with a fully functioning environment management cell with laboratory facilities for the monitoring of the industrial area
- The sewage water should be treated and reused to water the plants of green belt surrounding the industrial area
- Such treated water should be also used for cooling and plumbing activities
- There should be zero disposal of solid and liquid industrial wastes in only channelized through proper disposal methods
- Initiatives are undertaken to build storm water drainage passages as according to contour levels to minimize urban flood and water logging
- All the top soil layers excavated during the construction of industrial sites should be restored and used for horticultural activities and landscape development
- Samples of soil and ground water should be tested regularly in the industrial sites of Sompura to minimize the risk of health hazard
- Hazardous wastes, if generated should be kept minimum and channeled out safely
- The generators used for industrial activities have been instructed to be run by diesel with less Sulphur content to reduce pollution
- The noise pollution has to be kept minimum with no honking zone demarcations
- The fly ashes generated as industrial wastes may be further utilized as raw materials for buildings
- Usages of glass may be lowered by 40% and double coated glass windows may be used to enhance reflection of light, hence maintaining the temperature of the buildings to its minimum;
- This would initiate less consumption of electricity as use of air conditioners may be reduced
- A green belt of width 15 meters should be marked around the industrial sites which may be planted with rare local plant species
- As the industrial sites are planned to be demarcated by the boundaries and walls along with concreted fences, provisions of weeping holes (to allow passage of rainwater into the soil recharging the ground water levels) have been made

- Also, the surface runoff and roof runoff water may be collected, treated and separated from suspended matter before passing through the recharge wells and kept ready for dry weather seasons
- All kinds of traffic congestions may be reduced and checked with guidelines
- The usages of less power consuming light should be encouraged and after their disposal should be sent to recycle factories
- Efforts are also made to use solar panels for lighting purposes
- The building plans strictly prohibit residential and other commercial units to be closely spaced in order to allow fresh air and light to circulate well

However as far as lakes are concerned, there remain some disputes; it is often argued that the lake situated in Sompura remains polluted with continuous release of leachates and wastes from the nearby firms (Thakur A., 2023). It is also said that the migratory birds like cranes often flocked to the lake as it contained many fish and frogs, but repetitive waste disposals and uncanny odor have hindered such activity (DHNS, 2016). Initiatives are being taken at the state level to maintain the cleanliness of the lakes and wetlands in Bengaluru Metropolitan Region along with its fringe area by de-silting those already choked and using those mud and silt as chief raw materials for the highway and road constructions (Menezes, N., 2022). For the villages particularly, Bharateepura, Beeragondanahalli, Nidavanda, Pemmanahalli, Maralukunte, Hosahalli and Hanumantapura certain environmental norms have to be followed for building an industrial hub (GOK, 2019). These are as marked below;

(1) Individual Industrial Units would install effluent-treatment Plant
(2) The units would provide dust suppression systems with water sprinkling methods to minimise air pollution
(3) There would be provisions for dual pipes to use the treated sewage water for toilet flushing, gardening etc to promote zero wastage of water
(4) The noise levels of the machines should not exceed 55 dB(A) during day and 45 dB(A) during night time (however for Industrial sites 75 dB (A) (day) and 70 dB (A) (night
(5) The projects should be well informed through at least two local newspapers (one in the vernacular language) to make the residents aware of the related environment clearance certificates from concerned offices

As planned and guidelines being given, it is also important to see whether these have been maintained; the Karnataka State Pollution Control Board, monitored the noise pollution levels at different locations of Sompura and its adjacent areas which exhibit values within the set limits. Nidavanda and Hosahalli are the industrial sites which also show values considerably lower than the set limit (CPCB, 2021). Table -2 reveals the scenario of noise and air pollution in the study area.

Table-2: Levels of Noise in dB(A)-2021 and Levels of Air Pollution-2021

Monitoring Points	Actual		Limit/Desirable	
	Day	Night	Day	Night
Bharateepura	54.00	43.90	55	45
Beeragondanahalli	54.30	44.60	55	45
Nidavanda	53.90	43.70	75	70
Pemmanahalli	54.20	44.80	55	45
Lakshmanapura (outside Sompura)	52.50	42.40	55	45
Hosahalli	52.30	43.90	75	70
Hanumantapura	52.30	42.40	55	45
Madenahalli	54.50	41.60	55	45
Thyamagondlu (outside Sompura)	53.60	42.90	55	45

Pollutants/ Components	Permissible Limits*	Minimum Values	Maximum Values	Average Values
Suspended Particulate Matter SPM10, (µg/m3)	100	59.6	66.10	63.00
Suspended Particulate Matter SPM2.5 (µg/m)	60	21.5	25.80	23.80
Nitrogen Dioxide NO2 (µg/m3)	80	16.9	23.40	20.20
Sulphur dioxide as SO2 (µg/m3)	80	8.30	14.60	11.20

Source: Karnataka Industrial Development Board, Bengaluru (2021)

Note: *CPCB=National ambient air quality standards

Conclusion

Sompura gives a much clearer picture as it promotes industries, in the question of environment conservation and maintenances. This may act as a good example for any such urban planning measures in the Asian cities. In the conclusion stage, the analysis done so far has been tabulated in order to get a hold of the overall situation of Sompura at present. The following are some opportunities and concerns as well which may help the city planners and the government officials for taking further precautions in achieving sustainability. The opportunities here are firstly, the industrial activities in Sompura have been integrated as Sompura-Dobbaspet Industrial hub for realizing positive economies of scale and this would lead to the realization of advantages of agglomeration economies through the setting up of ancillaries, medicines, telephone towers, solar panels related firms. Also, components of Environment conservation have been strictly followed by checking the levels of air and noise and dust pollution. But there are still few concerns like, gender disparity in the levels of literacy is still on higher side. There are also complains on continuous waste disposal activities taking place in the lakes and wetlands adjacent Sompura industrial area which are affecting the associated eco-system. The environment-activists may argue that growing industries and infrastructures may outweigh the efforts of environment conservation over-time and most importantly, with rapid industrialization and new firms coming up, there is always a threat for the local and unskilled population to be further marginalized.

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