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Hoping all of you shall enjoy our endeavors and those of our contributors.

Editor



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Trend, Growth Dynamics and Instability in Major Food-Grain of Bihar

Vijay Kumar[*]
Dr. Sanjay Kumar[**]

Abstract

In agrarian states like Bihar, food grain production plays a pivotal role in ensuring food security. Beyond food security, it also contributes to ensuring livelihoods and economic stability. Following the bifurcation of the state in 2000, the Bihar economy's reliance on agriculture has increased significantly. Bihar ranks among India's poorest states. Despite agriculture making a substantial contribution to the state's economy, Bihar's agricultural sector has witnessed considerable instability in food grain production over time. This study examines the trends, causes, and policy implications of this instability. Its primary objective is to understand the underlying factors responsible for fluctuations in production. This analysis is based on secondary time-series data pertaining to a specific period i.e., from 2010-11 to 2024-25for major food grains, such as rice, wheat, maize, and pulses. For analysis, statistical tools such as growth rate analysis and volatility indices (Cuddy-Della Valle Index) have been employed to measure the extent and patterns of variation in production.

Key words: - Agriculture Instability, Bihar Agriculture, Cuddy–Della Valle Index, CAGR (%)

Introduction

Since the state's bifurcation, agriculture has remained the backbone of Bihar's economy, playing a pivotal role in livelihoods, food security, and economic development. A significant portion of the state's population depends, either directly or indirectly, on agriculture for its livelihood. Despite the gradual growth of the industrial and service sectors, agriculture continues to be the primary economic activity. Bihar's agrarian structure is characterized by small and marginal landholdings. The state faces immense demographic pressure on its land resources, and farmers have limited access to modern agricultural inputs. The production and productivity of food crops are highly susceptible to natural, economic, and technological factors.

Food grains occupy a preeminent position in Bihar's cropping pattern. Rice is the principal crop, cultivated primarily during the Kharif season. Wheat ranks second to rice, serving as the leading crop of the Rabi season. In certain districts, maize has emerged as a significant crop, a development attributed to its commercial utility and rising demand. Pulses are leguminous crops rich in protein an essential nutrient for human health. Collectively, these food grains constitute the foundation of food security within the state and play a crucial role in meeting the consumption requirements of a rapidly growing population. Any fluctuation in their production not only directly impacts food availability but also has a direct bearing on the income levels of farmers.

Agricultural production particularly that of food grains is inherently subject to instability. Instability in agriculture refers to the fluctuations or variability in production levels observed over time. Statistically, these fluctuations can also be measured through changes in the area under cultivation, total production volume, and productivity levels. In Bihar, such instability often stems from climatic uncertainties, such as erratic rainfall, floods, and drought conditions. Additionally, it arises from structural constraints, including inadequate irrigation facilities, weak infrastructure, and limitations in the adoption of modern technology. Dependence on monsoon rains exacerbates the inherent variability in agricultural production, making it difficult to achieve sustained growth.

The issue of instability in food grain production is very important because it has far-reaching consequences. First and foremost, it directly impacts food security by creating unpredictable fluctuations in food availability. In years of low production, food grain shortages emerge, leading to increased reliance on

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imports from other states. Such shortages consistently cause food prices to skyrocket. Second, this instability has a profound impact on farmers' incomes. Since a large proportion of farmers in Bihar consists of small and marginal landholders, they are particularly vulnerable to production-related shocks. Fluctuations in production negatively impact incomes, increase debt, and reduce the ability to invest in future agricultural activities. Third, instability has long-term effects at both the agricultural and policy levels. This hinders agricultural planning and investment, and slows overall economic growth.

In light of these concerns, it becomes imperative to systematically analyse the nature and extent of instability in food grain production in Bihar. Although agricultural production has witnessed some improvement owing to policy interventions and technological advancements, the persistent variability in output raises critical questions regarding the sustainability of growth in this sector. It is necessary to examine whether the growth observed in food grain production is stable and reliable, or if it is accompanied by significant fluctuations that undermine its benefits. With these considerations in mind, this study attempts to statistically analyse the fluctuations in food grain production during the period from the year 2010 to 2024. Through which changes in the area, production, and productivity of food grains specifically rice, wheat, maize, and total pulses can be measured.

Review of Literature

The growth of the agricultural sector has always been a major topic in India. In 1982, Hazell conducted a study focusing on the volatility of Indian food grain production. Since then, assessing the volatility of agricultural products has become a major research topic. Numerous studies have been conducted in different parts of the country, attempting to measure the growth and volatility of agricultural products. Studies by Hazell (1982), Mahendra Dev (1987), Saha and Swaminathan (1994), Larson et al. (2004), Sharma et al. (2006), Chand and Raju (2009), Kumar and Jain (2013), Tiwari et al. (2017), Kihla et al. (2021), and Chauhan et al. (2024) have made significant contributions to the literature on agricultural volatility in India. All of their studies have focused on examining the nature, measurement, and determining factors of crop production variability at regional, national, and international levels. They believe that although production has increased due to technological changes, instability in the agricultural sector is continuously increasing due to various factors. This instability makes farming more uncertain and risky, negatively affecting farmers' income, jobs, food supply, and their ability to invest in new agricultural technologies.

The study by **Chand and Raju (2009)** analysed estimates of instability in Indian agriculture at both the national and state levels. This analysis encompassed the total cropped area, as well as major crop groups and individual commodities. They introduced a Cop Pock's Instability Index methodological approach for quantifying instability. This methodology featured an instability index based on the standard deviation of the 'logarithmic ratio' of consecutive observations. Using national and state-level time-series data on area, production, and yield, the post-independence period was divided into three distinct technological phases, deconstructing two separate datasets. Data collected during the post-Green Revolution period (1968 to 2007) shows that yield differences increased with the spread of new technologies. Dividing the post-Green Revolution period into two sub-periods reveals that differences increased during the initial years of new technology adoption. Conversely, they narrowed rapidly after 1988 as technology became more diffuse. Another corollary of these results is that the impact of factors such as new technology may be completely different when comparing short-term and long-term time frames.

Kihla. et al. (2021) conducted a study on the banana crop in South Gujarat. This study aimed to examine the growth and volatility in area, production, and productivity of the banana crop over a 15-year period (from 2004-05 to 2018-19). The Compound Annual Growth Rate (CAGR) was used to measure growth, while the exponential function was used to analyze the CAGR. The estimated trends revealed significant increases in area, production, and productivity; all three variables were found to be statistically significant. In contrast, the Cudi-Della Valle index was used to analyse the volatility index. According to the CDVI, the level of volatility in these three variables, namely area, production, and productivity, was found to be low (in the range of 0–15%).

Chauhan et al (2024) conducted an empirical study on the volatility and growth scenarios of potato production in India based on data from 1950-51 to 2020-21. The study found that potato production across India has increased over the past seven decades, but volatility persists in Bihar, Gujarat, and West Bengal. Despite fluctuations, these states contribute over 80% of India's total potato production. Stable growth in this sector is crucial for India's vegetable production and farmers' incomes. Therefore, research and technology are crucial for the development of the potato industry.

Methods and Methodology

This study is based on data regarding area (in 000' hectares), production (in thousand tons), and productivity (kg/hectare) for the period of 15 years i.e.,(from 2010–11 to 2024–25). These data were collected from the Department of Agriculture and Farmers Welfare, Government of Bihar. Various statistical and econometric tools have been employed to measure agricultural growth and instability. Among these, the most widely utilized methods include: Compound Annual Growth Rate (CAGR), Coefficient of Variation (CV), Cuddy-Della Valle Instability Index (CDVI), Cop pock's Instability Index (CII), regression analysis, and trend analysis. In the present study, the CDVI has been utilized to measure instability and this instability index is computationally simple and stands as the most widely used method for measuring instability in time- series data; moreover, it is universally applicable. Consequently, it serves as a superior metric for assessing instability in agricultural production. A lower value of this index indicates lower instability in the data, whereas a higher value signifies greater instability. The CDVI was developed by Cuddy and Valle (1978) specifically to measure instability in time-series data characterized by a distinct trend. A CDVI value falling between 0% and 15% is classified as low instability; a value between 15% and 30% is considered moderate instability; and a value exceeding 30% is deemed high instability (Rakesh Sihmar, 2014). The CDV Index corrects the Coefficient of Variation (CV) in the following manner:

Cuddy – Della Valle Instability Index (%) i.e., $CDVI = CV \times \sqrt{1 - Adj.R^2}$

Where: A Coefficient of Variation ((C.V. (%)) = $\frac{Standard\ deviasion}{Mean} \times 100$

$\overline{R^2}$ (%) = Adjusted coefficient of determination

Results and Discussions

To assess the growth and instability in the area, production, and productivity of cereal crops specifically rice, wheat, maize, and pulses data covering a 15-year period (2010–11 to 2024–25) is presented in Table -1, as follows:

Table-1: Area, Production and Productivity of Rice, Wheat, Maize and Pulses in Bihar during the period 2010-11 to 2024-25

Area in ('000 hectare), Production in ('000 tonnes), Productivity in (Kg/ha.)

Years	Rice			Wheat			Maize			Total Pulses		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
2010-11	2832	3102	1095	2104	4098	1948	646	1440	2230	612	538	878
2011-12	3324	7163	2155	2142	4725	2206	675	1611	2386	524	511	975
2012-13	3299	7529	2282	2208	5357	2427	686	2476	3611	516	543	1052
2013-14	3131	5506	1759	2009	4738	2358	732	2112	2884	500	522	1044
2014-15	3263	6357	1948	2154	3987	1851	707	2340	3313	575	494	859
2015-16	3232	6802	2104	2111	4736	2244	705	2517	3571	498	421	845
2016-17	3340	8239	2467	2106	5111	2427	721	2690	3732	493	462	936
2017-18	3307	8093	2447	2101	6104	2905	677	2355	3476	476	454	954
2018-19	3160	6156	1948	2157	6466	2998	669	2483	3708	479	453	946
2019-20	2886	6298	2182	2150	5580	2595	673	2003	2975	457	334	731
2020-21	3021	6747	2233	2223	6150	2767	649	2084	3211	449	377	839
2021-22	3091	7717	2496	2239	6224	2780	663	2669	4026	435	388	891
2022-23	2863	7023	2453	2199	6506	2958	748	4380	5854	434	414	954
2023-24	3110	7902	2541	2276	7168	3150	955	5709	5975	468	399	852
2024-25*	3215	8441	2625	2251	7120	3164	859	4901	5706	448	401	893

Source: *Department of Agriculture & Farmers Welfare (DA&FW), Government of Bihar.*

**Data for the year 2024-25 is of 3rd Advance Estimates*

Table 1 shows that the crop area has remained mostly unchanged over the years, with no major expansion in land use. The increase in production of rice, wheat, and maize is relatively stable and supports food security, and this growth is mainly due to improved yields rather than an increase in area. This shows improvement in technology and inputs. Rice and wheat have steady yield growth with small changes, so they are stable crops. Maize shows a strong increase in yield, which means it responds well to modern methods. Pulses have low and unstable yield, which shows weakness in this crop.

Table No.-2: Estimated Compound Annual Growth Rate (CAGR) % in Area, Production and Productivity Rice, Wheat, Maize and Pulses Crops in Bihar

Characters	$\bar{R}^2$ (%)	P-value	CAGR (%)	C.V (%)	CDVI (%)
Rice					
Area	-1.63	0.39	-0.28	5.45	5.51
Production	24.70	0.03	3.02	19.58	16.96
Yield	46.28	0.00	3.31	17.91	13.07
Wheat					
Area	42.69	0.01	0.50	3.29	2.48
Production	77.43	0.00	3.74	18.28	8.77
Yield	72.27	0.00	3.23	16.16	8.55
Maize					
Area	25.32	0.03	1.33	11.75	10.18
Production	55.18	0.00	7.05	43.96	29.49
Yield	63.98	0.00	5.64	31.16	18.70
Pulses					
Area	66.86	0.00	-1.85	10.27	5.90
Production	67.91	0.00	-2.60	14.27	8.07
Yield	8.35	0.16	-0.77	9.15	8.78

From the Table 2, CAGR and CDVI results show clear differences among crops. Maize has high growth but also high instability, so it is risky. Wheat has moderate growth with good stability, so it is more reliable. Rice has low growth but remains fairly stable, and its growth comes mainly from yield. Pulses show negative growth and instability, which indicates decline. Overall, crops with higher growth tend to be more unstable, while stable crops grow slowly. Overall, there is a trade-off between growth and stability, where high-growth crops like maize are more unstable, while traditional crops like wheat and rice remain more stable.

Result and Discussion:

Table 2 presents the CAGR and volatility in the area, production, and productivity of rice, wheat, maize, and total pulses crops. The CAGR statistics indicate that the cultivated area for rice and total pulses has experienced a negative growth rate. Maize recorded a growth of (1.33%), while wheat grew by only (0.50%). In terms of production, the highest growth was observed in maize (7.05%), followed by wheat (3.74%) and rice (3.02%), whereas total pulses recorded a growth of (-2.60%). Regarding productivity, maize registered the highest growth (5.64%), followed by rice (3.31%) and wheat (3.23%). At the productivity level, total pulses also recorded a negative growth of (-0.77%).

Thus, across all three parameters area, production, and productivity the growth rate of maize, as measured by CAGR, can be considered satisfactory; conversely, the growth rate of total pulses can be deemed unsatisfactory.

The P-value indicates that all three variables (area, production, and productivity) were statistically significant. The value of the Coefficient of Variation reflects the variability present within the variables. A low Coefficient of Variation indicates low variability in the data, whereas, conversely, a high value indicates greater variability. Based on this, lower variability was observed in wheat, while higher variability was found in rice.

The instability in the area, production, and productivity of rice, wheat, maize, and total pulse crops was measured using the 'Cuddy-Della Valle Index' (CDVI). In terms of area, higher instability was observed in maize (10.18%) and total pulses (5.90%) compared to rice (5.51%) and wheat (2.48%).

Regarding production, significantly higher instability was found in rice (16.96%) and maize (29.49%) compared to total pulses (8.07%) and wheat (8.77%).

At the productivity level, significantly higher instability was observed in rice (13.07%) and maize (18.70%) compared to wheat (8.55%) and total pulses (8.78%).

Thus, the CDVI indicates that: In wheat and total pulses, the level of instability across all three variables was low, as it remained below 15 percent. In rice, the level of instability was low for two variables (area and productivity), while in maize, it was low for only one variable (area). Consequently, we can conclude that the level of instability was high for one variable (production) in the case of rice, and for two variables (production and productivity) in the case of maize, as these figures exceeded 15 percent.

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Trade union and the Plantation Labours of North Bengal: Struggle for Decent Wages

Vikash Mandal[*]
Dr. Kumar Amarendra Narayan[**]

Abstract

Tea plantation industry in India is one of the largest organised sector industry and second largest employment provider sector of the country. It has its own labour pattern and trade union system. Despite of having union system in tea Garden, wages of tea garden workers are comparatively low than the other plantation industry. Its wage is also lower than the government prescribed rate given to other sector. With such low level of wages, workers are finding it hard to make ends meet. Tea garden has its economic significance, but the workers and their Trade Union is substantially lower in power than that of other organised sector industries' Trade Union. They are unsuccessful in enforcing statutory minimum wage. The government machinery and political parties indirectly favoured the management when dealing with the grievances of the worker. Laxity of government and weakness of Trade Union have rendered management to exploit the vulnerable working class. The present paper will explain the issue relating to the wage determination and trend of wage increment. Paper will also examine the role of Trade Union in wage rate negotiation.

Keyword: Tea Plantation, Trade Union, wages

Introduction

For the betterment of individual or group of individual depends not only the monetary benefit they receive but also depends on mental and emotional status. "The term welfare implies that the deliberate efforts made for the advancement of the individual or community (Ghosh,2006)." Its aim to brought happiness and well-being among the worker by improving health and hygiene condition, education and housing facilities, drinking water facilities, safety and protection.

Trade union movement in tea garden and workers welfare

In Bengal tea is mainly cultivated in the northern part of the state (Alipurduar, Jalpaiguri, and Darjeeling). In the earlier phase of tea cultivation, tea workers were unorganised. As a result, they could not enunciate their wages, their demand and problems faced into their day to day activities from the British Raj. They were forced to accept low wages as fixed by tea estate owned by British planters. Wages were such low level that even when the family members contributed to the wage earning, it together constituted between 62 to78 percent of family expenditure. The British planters had their own army to tackle the garden and workers. In north Bengal these army known as North Bengal mounted Rifles. They were formed with a view to maintain law and order in the tea Garden and also to monitor and prevent the workers from forming any organisation(Bhowmik, 2011).

Statement of the Problem

Tea plantation workers of the India has been passing through crisis since last one hundred years. Industries have changed their hand from British to Indian but the status of the workers have not changed. They always get low wages compared to other plantation industries and receive least benefits from the planters. They get low wage even the government prescribed minimum wages. In duar's tea garden, not only wage amount is low, but also they get irregular wage payment, non-payment and or reduction of bonus, provident fund and gratuity. In addition to the monetary benefit received by the workers, living condition is not proper with inadequate drinking water facilities, poor

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health facilities, improper housing facilities, least educational facilities. Facing these problem, they find themselves in the difficult situation. That's why they are alienated from the main stream of society.

Objectives/ Hypothesis of the Study

In the background of above problem, our research objectives are:-

I. To find the effectiveness of trade union in collective bargaining and wage fixation

II. To find the effectiveness of plantation labour Act 1951

Research Methodology

Research methodology is the systematic study of the research. It is the process and steps followed during the research study. Present study based on the secondary data collected from available books, articles, trade union related report and tea gardens related report and publications. After study the available data we analyse the data accordingly to get the final output

Trade Union in Collective Bargaining and Wage Fixation:

Trade union as dispute settlement mechanism in industrial sector arose with the advent of factory system in India. Indian Trade union act 1926 provided recognition to trade union and trade union activities in tea garden. First, trade union movement in doors tea garden was initiated by Bengal- Assam rail road workers (Bhowmik, 1981).

The Royal commission on labour, 1930 strongly recommended that the wage fixing machinery must be set up in the tea industries even though the planters felt that fixing of minimum wage was absolutely unnecessary (Bhowmik, 1980).

The Rege commission in 1944 felt that workers no power in wage fixation process and had to accept with the amount fixed by the management which were exploitive in nature.

Plantation enquiry commission states that,' there is a wage differential between men and women, the latter though more efficient in plucking also get a less wage (savur, 1973). Despite the legal provision of equal remuneration Act 1976, there still existed a wage differential between women workers and to their male counterparts.

Collective Bargaining

One of the most crucial role of trade unions have their active participation in wage negotiation through collective bargaining. Periodic wage revision under tripartite agreement are largely the outcome of union pressure and mobilisation.

After the expiry of prevailing wage agreement between workers and planters, Trade union submit a charter of demand to the worker organisation. In this charter Trade union of workers mention wage hike, incentive, bonus, overtime and some other benefit. But charter primarily focused on demand for wage hike. Both the workers and employer union start bipartite level talk. Most of the time these talk fail to fulfil the union demand. In this situation matter of wage determination moves to state government. State government call both parties to negotiate the wage level. In general there is huge difference between wage demanded by the workers and wage proposed by the employers. State government mediate in this regards. Their main focus to narrow down the gap between the differences. Finally wage gap narrowed down at tripartite talk. In all the tripartite talk collective bargaining ends in favour of the employer.

Wage Fixation

Tripartite agreement between the parties generally comes after the expiry of the term. The terms of agreement valid for three years. There are some wage agreement in which settlement of wage rate are undermentioned in table no 1.1:

Table No.1.1 : Settlement of wage rate as on 21.7.1994

Sl. No.	Effective from	Rate of wage
1	w. e. f 1.04.1994	2.50
2	w. e. f 01.04.1995	2.50
3	w. e. f 01.04.1996	2.00

***Sources**: Indian Tea Association and Labour department*

Table No. 1.2

Settlement of wage rate as on 25.7.2005

Sl. No.	Effective from	Increased Rate of wage
1	w. e. f 1.04.2005	2.50
2	w. e. f 01.04.2006	2.50
3	w. e. f 01.04.2007	3.00

Sources: *Indian Tea Association and Labour department*

Government of West Bengal constituted a minimum wage advisory committee in Feb. 2015 for a tenure of two years on fixation and revision of minimum wages for Tea Garden workers.

Table No. 1.3

Settlement of wage rate as on 20.02.2015

Sl. No.	Effective from	Rate of wage
1	W .e. f 1.04.2015	112.50 (increased Rs.17.5
2	W. e. f 01.04.2016	122.50 (increased Rs.10)
3	W. e. f 01.04.2017	132.50 (increased Rs. 10)

Source: *West Bengal Labour Department*

Rate of extra leaf price as per 20.02.2015 were determined as follows:

I. for output up to 6 kg above Base Task @ 3.00 per Kg

II. for output above 6 Kg and above Base Task @ 3.50 per Kg

Last wage settlement was singed on dated 20.02.2015. After that government of west Bengal issued several memorandum regarding the increase of wages. Planters association accepted accordingly to avoid plantation labour unrest despite their worsening financial condition.

Thereafter, west Bengal labour Commissionarate issued wage notification through different wage notification.

Effectiveness of plantation labour Act 1951

The Plantation labour Act 1951 was passed just after independence to address the labour working in the Plantation of Tea, Rubber, Coffee and other Plantation having more than 30 worker. Colonial Plantation systems were characterised by indenture labour system, unhygienic working condition, with long working hours without rest. I in these respect, state interventions were minimal. To meet the constitutional demand for social justice, labour dignity and welfare state under section 38 and 39 and 42 of Indian constitution, government passed the Plantation labour Act 1951.

The Plantation act incorporates a paternalistic welfare model in which employer have all the responsibility for housing, healthcare, sanitation and education. The act provide power to employer to regulate working hour and leave. The framework have its own economic viability in continuous operation of Plantations but the system is helpless during the period of crisis (Ghosh, 2014).

The act, apply to all Plantation across the nation where Plantation done at 25 acre or more workers employed at least 30 workers. The act covers tea, Coffee, Rubber and cinchona Plantations.

Discussion and Conclusion

There were lot of trade union movement activities performed for the betterment of the workers of the tea garden. And there is wage fixation mechanism is active in the tea plantation area of the west Bengal but wage rate in tea garden workers is comparatively low to the other sector of the workers. In response of such low wage tea garden management have an argument that wage paid to workers is not individual basis but they consider family as a unit. Further they have argue that garden management provide certain non-statutory benefit to the workers in addition to their normal wage.

Plantation labour act were passed by the government to protect and safeguard the workers right. But tea garden management often uses the loophole of the act to avoid the workers right.

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AI, Social Media and Democracy in India: Transforming Political Communication and Voter Behaviour

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Abstract

The rapid expansion of artificial intelligence (AI), social media platforms and algorithmically mediated communication is transforming the relationship between citizens, political actors and democratic institutions in India. Social media has already altered political communication by enabling political parties and candidates to communicate directly with citizens, bypassing several traditional media gatekeepers. The emergence of generative AI, however, represents a further transformation. Political communication is increasingly shaped not only by human actors but also by algorithms capable of generating, recommending, personalising and amplifying political content. This development has created new opportunities for political participation, political mobilisation and access to information, while simultaneously generating concerns relating to misinformation, deepfakes, political manipulation, algorithmic bias, polarisation, privacy and electoral integrity.

This paper examines the changing nature of political communication and voter behaviour in India in the age of AI-mediated social media. It adopts a qualitative, conceptual and analytical approach based on existing academic literature, recent research, policy documents and contemporary developments in India. The paper particularly examines the relationship between algorithmic communication, political information, voter perception and democratic participation. It also discusses the recent study by Manya Sonny, Vipin Benny and K. Lakshmi, "Beyond echo chambers: How network homophily and algorithmic recommendations shape political polarization among young Indian voters," which provides recent empirical evidence concerning algorithmic recommendations, echo chambers and political polarisation among young Indian voters.

The paper argues that the central democratic challenge is no longer simply the circulation of false information. It is the changing architecture through which citizens encounter, evaluate and interpret political information. AI can simultaneously strengthen and weaken democracy: it can widen political participation and access to information while also increasing the scale, speed and sophistication of political manipulation. The paper concludes that India's democratic resilience will depend on a combination of responsible AI governance, platform accountability, transparent political communication, media and digital literacy, and institutional capacity to protect electoral integrity without undermining legitimate political expression.

Keywords: Artificial Intelligence, Social Media, Democracy, Political Communication, Voter Behaviour, Algorithmic Politics, Deepfakes, Misinformation, Political Participation, India

1. Introduction

Democracy depends not only on elections but also on the quality of communication through which citizens understand political issues, evaluate political leaders and make political choices. In a representative democracy, political communication performs several important functions. It provides information to citizens, enables political parties to communicate their programmes, allows governments to explain policies and creates opportunities for citizens to express political preferences.

For much of the twentieth century, newspapers, radio and television were the principal institutions through which political communication took place. These institutions acted as important gatekeepers between political actors and citizens. The emergence of the internet and social media fundamentally changed this arrangement. Political parties and candidates could increasingly communicate directly with citizens, while ordinary citizens could themselves produce, circulate and comment upon political content.

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India has been at the centre of this transformation. With a very large and diverse electorate and widespread use of mobile internet and social media, digital platforms have become important spaces for political communication. Election campaigns increasingly use social-media platforms not simply to distribute information but to create narratives, mobilise supporters, respond to opponents and reach specific groups of voters.

The emergence of artificial intelligence has added a new dimension to this transformation.

Generative AI can produce realistic text, images, audio and video. Algorithms can analyse user behaviour and determine which content is more likely to attract attention. Political messages can therefore be generated, personalised and amplified at a scale that was difficult to imagine in the traditional media environment.

This raises a fundamental question for democratic politics:

What happens to political communication when the information environment in which voters make political judgements is increasingly shaped by artificial intelligence and algorithmic systems?

The question is particularly important in India because political communication takes place in a highly diverse linguistic, social and cultural environment. Information travels rapidly through platforms such as WhatsApp, Instagram, Facebook and YouTube, while political communication increasingly takes place through short videos, memes, visual narratives, influencers and personalised feeds.

The democratic implications are complex. On one hand, AI can make political communication more accessible and allow political actors to communicate with citizens in multiple languages and formats. It can support voter education, translate political information and enable citizens to engage with political issues more easily. On the other hand, the same technologies can be used to create convincing false content, manipulate political narratives and increase uncertainty about what is authentic.

The problem is therefore not simply that "AI is dangerous for democracy". Such a conclusion would be too simplistic. The democratic consequences of AI depend on how the technology is designed, used, regulated and understood by citizens.

This paper argues that India is moving from an era of digital political communication towards an era of algorithmic political communication, in which AI and platform algorithms increasingly influence not only what political information is produced but also what citizens encounter and how political information is presented to them.

2. From Mass-Mediated Politics to Algorithmic Politics

Political communication can broadly be understood as the exchange of political information, ideas and meanings among political actors, media institutions and citizens.

The traditional model was largely linear:

Political actors → Mass media → Citizens

Newspapers and television determined, to a considerable extent, which political issues received visibility. Citizens generally consumed political information rather than actively producing it.

Social media changed this model:

Political actors ↔ Platforms ↔ Citizens

The boundaries between producers and consumers of political information became less clear. A citizen could simultaneously be a voter, content producer, political commentator and political campaigner.

This transformation created what can be described as a networked political environment.

AI introduces another transformation:

Political actors + AI → Algorithms → Personalised information environments → Citizens

In this new environment, algorithms determine which messages receive visibility. Generative AI can produce political content, while recommendation systems can amplify particular forms of content because they are predicted to generate engagement.

Political communication therefore becomes increasingly personalised and automated.

The important question consequently changes from:

Who controls political messages?

to:

Who controls the systems through which political messages are generated, selected, amplified and presented to citizens?

This is the beginning of what may be called algorithmic politics.

3. AI and the Transformation of Political Communication

Artificial intelligence can transform political communication in several ways.

3.1 Generation of political content

Generative AI can produce speeches, campaign messages, images, videos, audio recordings and social-media posts. Political communication can consequently be produced faster and at lower cost.

This has a democratic advantage. Smaller political organisations and candidates may obtain communication capabilities that were previously available mainly to organisations with substantial financial and technical resources.

However, the same capability creates risks. The cost of producing convincing false political content is also falling.

The distinction between genuine political communication and fabricated political communication can therefore become increasingly difficult for ordinary citizens.

3.2 Personalisation of political messages

Traditional political speeches generally addressed large audiences.

Digital political communication allows political messages to be targeted at specific groups.

AI can make this process more sophisticated by analysing patterns of online behaviour and generating content designed for particular audiences.

The political message received by one voter may therefore be substantially different from the message received by another voter.

This creates an important democratic concern.

In a healthy public sphere, citizens should be able to encounter different perspectives and participate in a shared political conversation. Excessive personalisation can instead create fragmented political realities in which different groups encounter different versions of political issues.

3.3 Algorithmic amplification

Not all content uploaded to a social-media platform receives equal visibility.

Recommendation systems decide, according to platform-specific criteria, which posts, videos or accounts users are more likely to encounter.

This means that political communication is not determined solely by political actors.

The architecture of the platform also becomes politically significant.

Content that generates strong emotional reactions may receive greater visibility because engagement is valuable to platform systems. Political content based on anger, fear, conflict or outrage may consequently compete effectively for attention.

This does not mean that algorithms automatically create polarisation. However, the architecture of algorithmic recommendation can influence the information environment in which political opinions develop.

4. Social Media and the Changing Indian Political Communication Environment

India's political communication environment has undergone a major transformation during the last decade.

Political parties now maintain extensive digital communication networks. Leaders communicate directly with citizens through social-media accounts. Supporters produce political content independently. Journalists use social media to distribute news. Influencers increasingly participate in political discussions.

The result is a political environment in which the distinction between journalism, political campaigning, political commentary and citizen-generated content is often blurred.

This has democratising potential.

Citizens who were previously excluded from mainstream media can participate in political conversations. Marginalised groups can use digital platforms to raise issues. Political campaigns can reach citizens directly. Young people can participate in politics without joining traditional political organisations.

At the same time, the same environment creates new vulnerabilities.

Information can circulate without conventional editorial verification. False information can be repeated until it appears familiar. Political content can be emotionally designed for maximum engagement. Satire can be presented as fact. Old images can be circulated as new events. AI can further complicate these problems by creating realistic synthetic content.

Thus, social media has not simply increased the quantity of political communication.

It has changed its speed, structure, participants and credibility mechanisms.

5. AI, Social Media and Voter Behaviour

Voter behaviour has traditionally been studied through factors such as political ideology, party identification, caste, class, religion, leadership perceptions, economic conditions, local issues and campaign strategies.

Digital media has added another important factor: the voter's information environment.

A voter increasingly encounters political information through social-media feeds rather than through a single newspaper or television channel.

This can affect voter behaviour through several mechanisms.

Information exposure

Citizens may become aware of political issues through social media.

Repetition

Repeated exposure can make a political claim appear more familiar and therefore potentially more credible.

Emotional engagement

Political content designed to provoke anger, fear, pride or enthusiasm can influence political reactions.

Social endorsement

Likes, comments, shares and the visible support of friends can influence perceptions of the popularity or credibility of political claims.

Personalisation

Algorithms can provide different users with different political information.

Identity reinforcement

Citizens may increasingly encounter content that confirms existing political beliefs.

These processes do not necessarily determine voting behaviour. Voters remain capable of critical judgement and may be influenced by many factors outside social media.

Nevertheless, the information environment can influence how political choices are formed.

Contemporary Illustration: The 2026 Gen-Z Protest at Jantar Mantar

The recent Gen-Z-led protests at Jantar Mantar in New Delhi provide a particularly relevant contemporary example of the changing relationship between social media, youth political participation and political communication in India. The protests, which emerged around concerns relating to examination irregularities, education and employment, demonstrated how digitally connected young citizens can move rapidly between online political expression and offline collective mobilisation. The movement received substantial attention through social-media platforms, where protest-related videos, slogans, commentary and political narratives circulated rapidly. Reports described the Jantar Mantar mobilisation as a major youth-led protest movement, with social media playing an important role in its visibility and mobilisation.

The significance of this episode for political science lies not merely in the size of the protest but in the changing nature of political participation. Earlier generations often depended on student organisations, political organisations, newspapers or television to coordinate and publicise political action. Digitally connected youth can now create political narratives, circulate them through social networks and attract public attention without depending entirely on traditional political organisations.

The episode therefore illustrates the democratic potential of social media as a mechanism of political mobilisation from below. At the same time, it also demonstrates the risks associated with a rapidly circulating information environment. Different interpretations of the protest, competing narratives and potentially misleading or decontextualised videos can circulate simultaneously. Indeed, fact-checking organisations subsequently identified old videos being circulated with false claims about renewed Jantar Mantar protests, illustrating how the same digital environment that facilitates mobilisation can also facilitate misinformation.

The 2026 Gen-Z mobilisation is therefore significant for understanding contemporary Indian political communication. It suggests that young citizens are not merely passive recipients of political messages delivered by political parties. They can themselves become political communicators, content producers and agenda setters. This represents an important movement from social-media consumption towards digitally enabled political participation.

6. Recent Evidence from Young Indian Voters

A particularly important contribution to the recent literature is the 2026 study by Manya Sonny, Vipin Benny and K. Lakshmi, titled:

"Beyond echo chambers: How network homophily and algorithmic recommendations shape political polarization among young Indian voters."

The study was published in Social Sciences & Humanities Open, Volume 13, June 2026, Article 102586. DOI: 10.1016/j.ssaho.2026.102586.

The study examined 825 young Indian voters and used Structural Equation Modelling through SmartPLS. It brought together Homophily Theory, Social Identity Theory, Selective Exposure, Algorithm Amplification and Motivated Reasoning to examine the relationship between network homophily, algorithmic recommendations, echo chambers and political polarisation.

Its findings suggest that homophilous networks and algorithmic content curation can contribute to stronger echo chambers, which in turn are associated with increasingly polarised political positions.

The demographic profile of the study is also revealing. Among its respondents, Instagram was the most frequently reported platform for political participation, followed by WhatsApp, Facebook and X/Twitter. The study therefore provides an important contemporary indication of the importance of visual and messaging platforms in the political information environment of young Indian voters.

The significance of this research for the present paper is twofold.

First, it demonstrates that algorithmic mediation is no longer merely a theoretical concern in the Indian context.

Second, it also identifies an area that requires further conceptual attention.

The study primarily examines political polarisation. The present paper expands the discussion by asking a broader question:

How does the AI-mediated information environment transform the process through which citizens encounter, interpret and evaluate political information?

Thus, polarisation represents one possible outcome, but it is not the entire democratic problem.

The deeper issue is the transformation of political judgement itself.

7. The Emergence of AI-Mediated Political Judgement

The concept of political judgement refers here to the process through which citizens evaluate political information, political actors and political issues before forming opinions.

In traditional political communication, citizens generally evaluated information produced by identifiable political actors and media institutions.

AI-mediated communication complicates this process.

A citizen may watch a video in which a political leader apparently says something controversial. The video may look authentic, the voice may sound genuine and the visual context may appear convincing. Yet the content may be synthetic.

The democratic problem is therefore not simply misinformation.

It is uncertainty about authenticity.

This creates a new chain:

AI-generated content → algorithmic distribution → citizen exposure → perceived authenticity → perceived credibility → political judgement

This paper refers to this process as AI-mediated political judgement.

The concept helps explain why AI creates a challenge that is different from conventional misinformation.

A false textual claim can potentially be fact-checked.

A sophisticated synthetic video can create an immediate emotional and visual experience before fact-checking becomes available.

Consequently, the democratic challenge increasingly concerns not only whether information is true but also whether citizens have sufficient capacity and institutional support to determine what is true.

8. Deepfakes and Synthetic Political Reality

Deepfakes represent one of the most visible manifestations of this problem.

Political deepfakes can take several forms:

- manipulated videos;

- AI-generated speeches;
- voice cloning;
- fabricated images;
- synthetic interviews;
- altered statements;
- digitally reconstructed political events.

The political consequences can be significant because visual and audio information often carries a strong perception of authenticity.
A written statement may be interpreted as an allegation.
A realistic video of a political leader apparently making the same statement may be perceived as evidence.
This difference makes synthetic political media particularly important.
The Election Commission of India has recognised this challenge. Its January 2025 advisory directed political parties to clearly label AI-generated or synthetic content and disclose its use in campaign material.
The broader objective was to promote responsible campaigning and help voters distinguish synthetic material.
The development of such guidelines demonstrates that AI-generated political communication has moved from a hypothetical technological concern to a matter of electoral governance.

9. Misinformation, Disinformation and the Speed of Political Communication It is useful to distinguish between misinformation and disinformation.
Misinformation refers broadly to false or inaccurate information circulated without necessarily requiring an intention to deceive.
Disinformation generally refers to deliberately false or manipulated information circulated with the intention of misleading.
AI can potentially increase both.
An ordinary citizen can unintentionally share an AI-generated false image.
A political actor or organised network could deliberately create and distribute synthetic content to damage an opponent.
The speed of social media makes the problem more difficult.
Political misinformation can travel rapidly across platforms before journalists, fact-checkers or election authorities can respond.
A correction may therefore reach fewer people than the original false claim.
This creates an asymmetry:
Creation is cheap and fast.
Verification is slower and resource-intensive.
This asymmetry is one of the central challenges of AI-mediated democracy.

10. Echo Chambers, Filter Bubbles and Political Polarisation
The relationship between algorithms and political polarisation requires careful treatment.
It would be incorrect to claim that algorithms alone cause political polarisation.
Political identity is influenced by social networks, ideology, family, community, political parties, traditional media and personal experiences.
However, algorithmic recommendation can interact with these existing factors.
Citizens may follow people with similar political opinions.
Algorithms may then recommend additional content that resembles what they have already consumed.
The resulting environment can strengthen existing beliefs.
This is particularly relevant to the recent Indian study by Sonny, Benny and Lakshmi. Their research conceptualises network homophily and algorithmic recommendation as interacting factors that strengthen echo chambers and contribute to political polarisation among young Indian voters.
The implication for democracy is important.
Democracy requires disagreement.
But democratic disagreement is productive only when citizens are capable of encountering opposing views and recognising the legitimacy of alternative perspectives.

An algorithmically fragmented public sphere can make such cross-cutting exposure more difficult.

11. Political Participation: The Democratic Promise of Social Media The discussion should not become overly negative.

Social media and AI can also strengthen democracy.

Digital platforms can:

- increase political awareness;
- make government information more accessible;
- facilitate political mobilisation;
- help citizens communicate grievances;
- increase youth participation;
- support political education;
- enable multilingual communication;
- give visibility to previously marginalised voices.

AI can further support these possibilities through translation, summarisation, accessibility tools and conversational interfaces.

For example, political information can potentially be made available in several Indian languages and in simpler formats.

This is particularly important in a country with enormous linguistic and educational diversity.

AI can therefore contribute to democratic inclusion.

The issue is not whether AI should be used in democracy.

The more important question is:

Under what conditions can AI be used without compromising democratic autonomy and political equality?

12. The Problem of Political Micro-Targeting

Another important concern is political micro-targeting.

Traditional political campaigning generally communicates with relatively broad groups.

Digital platforms can enable political messages to be targeted at specific categories of users.

AI can make targeting more sophisticated.

A campaign may potentially develop different messages for different demographic or behavioural groups.

The democratic problem arises when citizens are exposed to political claims that others cannot see or evaluate.

A shared public debate may therefore become fragmented into multiple personalised political realities.

This raises questions about:

- transparency;
- political advertising;
- privacy;
- informed consent;
- accountability;
- equality of political communication.

Political persuasion is a normal feature of democracy.

The concern begins when persuasion becomes so personalised, opaque and difficult to monitor that citizens cannot understand why they are receiving particular political messages.

13. Privacy, Data and Political Behaviour

AI-mediated political communication depends heavily on data.

Social-media platforms collect information about user behaviour, preferences and interactions. Political communication can potentially use such information to understand audiences and target messages.

The democratic significance of data therefore goes beyond privacy.

Data can become a resource for political influence.

The more political actors know about citizens, the more precisely political messages can potentially be designed.

This creates a tension between personalised political communication and citizens' informational autonomy.
Democracy requires citizens to make political choices freely. Excessively opaque data-driven persuasion can challenge that autonomy.

14. AI and the Changing Role of Political Parties

Political parties are not merely victims of technological change. They are active participants in it.
AI can help political organisations:

- generate campaign content;
- analyse public sentiment;
- translate messages;
- identify communication trends;
- personalise outreach;
- manage large volumes of digital communication.

This may increase the efficiency of political campaigning.
However, it also creates ethical responsibilities.
Political parties should not use AI simply because a technology is available.
They must consider whether a particular application is compatible with democratic principles.
A democratic political party should ideally distinguish between:
persuasion and deception, personalisation and manipulation,
political creativity and fabricated political reality.
This distinction will become increasingly important as synthetic media becomes more sophisticated.

15. AI, Social Media and Electoral Integrity

Election integrity traditionally concerns issues such as:

- free and fair voting;
- voter intimidation;
- electoral fraud;
- campaign finance;
- equal opportunity;
- accurate counting.

The digital environment adds another dimension: information
integrity.
A technically flawless election can still face a democratic information crisis if citizens make decisions based on large-scale fabricated political content.
The Election Commission of India has increasingly responded to this challenge.
The ECI's 2025 advisory on AI-generated content and subsequent measures concerning synthetic media indicate that election management is now dealing directly with AI-mediated political communication.
The institutional challenge is substantial.
Election authorities need to respond quickly enough to prevent harmful misinformation from spreading, while avoiding excessive intervention that could suppress legitimate political speech.
This produces a difficult balance:
Electoral integrity ↔ Freedom of political expression Neither
objective can simply be ignored.

16. Democratic Accountability and Platform Responsibility

Social-media companies occupy an increasingly important position in democratic communication.
They determine important aspects of the digital information environment through platform design, recommendation systems and content moderation policies.
This creates questions about accountability.
If an algorithm repeatedly recommends misleading political content, who is responsible?
The political party that created it?
The individual who uploaded it?
The platform that amplified it?

The algorithm designers?
The answer cannot always be simple.
Democratic governance therefore requires greater transparency regarding the operation of political content systems.
Platforms should be encouraged to develop mechanisms for:

- transparent political advertising;
- labelling of synthetic content;
- rapid response to election-related manipulation;
- independent auditing;
- researcher access to relevant data;
- user appeals;
- clear explanations of moderation decisions.

However, platform accountability should not become unrestricted private censorship.
The objective should be transparent and accountable governance, not simply greater content removal.

Contemporary Illustration: Meta and the Removal of the Prime Minister's Video

A particularly revealing contemporary example of platform power occurred in July 2026, when a video posted by Prime Minister Narendra Modi addressing young people about the ongoing examination controversy was temporarily removed from Meta's platform. The video was subsequently restored, with a Meta spokesperson stating that it had been removed in error. The incident attracted attention because the video was itself part of a political communication effort directed towards young and digitally active citizens following the Gen-Z protests.
The incident is important not because it establishes deliberate political censorship—there is no evidence sufficient to make such a claim—but because it illustrates the growing political significance of platform governance and automated content moderation.
When a major political message is uploaded to a social-media platform, its visibility is no longer determined solely by the political actor or by citizens. It can also be affected by the platform's technical systems, moderation policies and algorithmic processes.
The episode therefore raises an important question for democratic communication:
Who decides what political speech is visible in a digital public sphere?
In traditional media, editorial decisions were made by identifiable editors and institutions. In contemporary social media, decisions may involve a combination of automated systems, platform policies and human moderation. Errors in these systems can consequently have political consequences even when there is no deliberate intention to suppress political speech.
The Meta episode demonstrates that algorithmic governance presents a challenge for all political actors, irrespective of their ideological position. It therefore reinforces the need for greater transparency, effective appeal mechanisms and accountability in platform governance. At the same time, the incident should not be interpreted as evidence that platforms deliberately censor political speech; rather, it illustrates how technical errors and opaque moderation systems can affect democratic political communication.
In this sense, platform power has become an increasingly important dimension of democratic accountability in India.

17. Digital Literacy as Democratic Capacity

Regulation alone cannot solve the problem.
Citizens themselves require the ability to navigate an increasingly complex information environment.
Digital literacy should therefore be understood as a democratic capability.
Citizens should be able to ask:

- Who created this content?
- What is the original source?
- Is the video old or recent?
- Is the audio authentic?
- Is the image manipulated?

- Is the claim supported by independent evidence?
- Why am I seeing this content?
- Is this political advertisement clearly identified?
- Is the content designed primarily to provoke an emotional reaction?

These skills are particularly important because AI-generated content will continue to improve.
The solution cannot depend entirely on citizens identifying technical imperfections in synthetic media.
Institutional verification and platform transparency will remain necessary.

18. Youth and the Future of Indian Democracy

Young Indians occupy a particularly important position in this transformation.
The recent study by Sonny, Benny and Lakshmi demonstrates the importance of studying young voters in relation to algorithmic recommendation, social-media use and political polarisation.
The significance of youth is not simply that young people use social media more frequently.
They represent the generation for whom digital platforms are increasingly integrated into everyday political information.
This means that future political communication may become increasingly visual, personalised, short-form and algorithmically mediated.
Political parties, democratic institutions and educational systems therefore need to treat digital citizenship as an important part of democratic education.

19. Towards a Framework of Algorithmic Democracy

The developments discussed above suggest that Indian democracy is entering an era that can be described as algorithmic democracy.
This does not mean that algorithms replace democratic institutions.
Rather, algorithms increasingly mediate the environment within which citizens interact with those institutions.
The framework can be represented conceptually as:

Political actors
↓
AI-generated / AI-assisted political content
↓
Social-media platforms
↓
Algorithmic selection and amplification
↓
Personalised political information environment
↓
Citizen interpretation
↓
Political judgement
↓
Political participation / political behaviour

The entire process is influenced by:
Digital literacy + platform governance + regulation + political culture + media environment This framework highlights an important point:
AI does not directly determine voter behaviour.
Rather, it changes the conditions under which political judgement takes place.

20. Policy Recommendations

20.1 Mandatory transparency for synthetic political content

AI-generated or substantially AI-manipulated political content should carry clear and understandable disclosure.
The disclosure should be visible rather than hidden in technical metadata alone.

20.2 Stronger electoral AI guidelines

Election authorities should continue developing clear rules concerning:

- synthetic campaign material;
- deepfakes;
- voice cloning;
- AI-generated political advertisements; - impersonation of political leaders.

20.3 Platform accountability

Platforms should maintain transparent systems for identifying and responding to harmful synthetic electoral content.

20.4 Independent auditing

Independent researchers and appropriate regulatory bodies should be able to examine the political effects of recommendation systems while protecting user privacy and proprietary information.

20.5 Political-party responsibility

Political parties should adopt voluntary ethical codes concerning AI use in election campaigns.

20.6 Digital and media literacy

Digital literacy should be incorporated into civic education.

Citizens should learn not only how to use technology but also how to critically evaluate political information.

20.7 Protection of legitimate political expression

Regulation should not become a mechanism for suppressing criticism, satire, political disagreement or legitimate campaign communication.

The objective should be to prevent deceptive manipulation, not political disagreement.

20.8 Strengthening fact-checking capacity

Fact-checking organisations require technological capabilities capable of detecting synthetic media in multiple Indian languages.

20.9 Multilingual AI governance

India's linguistic diversity requires AI-governance mechanisms that work beyond English.

Synthetic political content in regional languages should receive equal attention.

21. Discussion

The transformation of political communication through AI presents a paradox.

The same technologies that can democratise communication can also increase the capacity for manipulation.

Social media has reduced the distance between political actors and citizens. AI can reduce that distance further. But the closer political communication comes to citizens, the greater the possibility that political messages can be personalised according to individual characteristics and behavioural patterns.

The democratic challenge is therefore not technological determinism.

AI does not automatically produce polarisation, misinformation or manipulation.

Political institutions, platform incentives, political cultures and citizen behaviour mediate its consequences.

This is why the recent Indian evidence on algorithmic recommendations and polarisation is important but should not be interpreted as proof that algorithms alone determine political behaviour.

The study by Sonny, Benny and Lakshmi provides evidence that network homophily and algorithmic recommendations can contribute to echo-chamber formation and polarisation among young Indian voters. The present analysis extends the discussion by placing this finding within a broader transformation of political judgement.

The central concern is ultimately democratic autonomy.

A voter should be able to encounter political information, evaluate it and make a political decision without being unknowingly manipulated by a fabricated political reality.

This does not require a return to traditional media.

Nor does it require rejecting AI.

It requires building democratic institutions capable of adapting to technological change.

22. Conclusion

Artificial intelligence and social media are fundamentally transforming political communication in India.

The first major transformation was the movement from mass-mediated political communication to networked communication. The second is now emerging through algorithmically mediated and AI-generated political communication.

In this new environment, citizens are not simply receiving political messages. They are entering personalised information environments in which political content is generated, selected, recommended, amplified and interpreted through increasingly complex technological systems.

This transformation offers substantial democratic opportunities. AI can improve political accessibility, facilitate multilingual communication, support political education and expand participation. Social media can give citizens new opportunities to express political opinions, mobilise around issues and communicate directly with political institutions.

At the same time, the risks are significant. Deepfakes, synthetic political content, misinformation, micro-targeting, algorithmic bias, echo chambers and political polarisation can weaken informed political judgement and public trust.

The recent study by Sonny, Benny and Lakshmi on young Indian voters provides important empirical evidence that network homophily and algorithmic recommendations can strengthen echo chambers and contribute to political polarisation. Such findings demonstrate the importance of studying the technological architecture of contemporary political communication rather than examining political behaviour only through traditional social and ideological variables.

However, the future of Indian democracy should not be understood as a simple contest between technology and democracy.

The central question is one of governance.

Who generates political information?

Who determines what citizens see?

Who is responsible when synthetic political information causes harm?

How can citizens identify manipulation?

And how can democratic institutions protect electoral integrity without restricting legitimate political expression?

These questions will become increasingly important as generative AI becomes more accessible and politically sophisticated.

India therefore needs an approach based on responsible AI, transparent political communication, accountable platforms, informed citizens and institutionally robust electoral governance.

The objective should not be to remove technology from democratic politics. That would neither be possible nor desirable.

The objective should be to ensure that technology remains a tool for democratic participation rather than an invisible mechanism of political manipulation.

Ultimately, the resilience of Indian democracy in the age of AI will depend not merely on technological innovation but on the capacity of democratic institutions and citizens to ensure that the power to shape political information remains accountable.

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Migration and the Left-Behind Population in Rural Areas of Uttar Pradesh

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Abstract:

Migration has become an important livelihood strategy for many rural households in Uttar Pradesh. Limited employment opportunities, small and fragmented landholdings, low agricultural income, seasonal employment and differences in wages between rural and urban areas encourage people to move in search of work. However, migration does not affect only those who leave their villages. It also has significant consequences for the family members who remain behind. Women, children and older persons often constitute the major part of this left-behind population. This paper examines the causes of migration from rural areas of Uttar Pradesh and discusses its economic, social and demographic effects on those who remain in the villages. Migration can improve household income through remittances and may help families meet expenses related to food, education, healthcare, housing and agriculture. At the same time, the absence of working-age members may increase women's responsibilities, create difficulties in childcare and elderly care, and produce emotional and social pressures. The paper contends that migration should be understood as a household livelihood strategy rather than simply as the movement of individuals from one place to another. The study is based on secondary data, particularly Census of India migration data and existing literature on rural migration. It concludes that policies should address not only migrant workers but also the needs of families and communities left behind.

Keywords: Migration, Left-behind population, Rural, Remittances, Women, Rural development, Labour migration.

1. Introduction:

Migration is an important part of social and economic change in India. People move from one place to another for employment, education, marriage, better living conditions and other reasons. Uttar Pradesh has a particularly important position in India's migration system because of its large rural population and differences in employment opportunities between villages and urban and industrial areas. In many rural parts of Uttar Pradesh, agriculture continues to be a major source of livelihood. However, agriculture does not always provide sufficient employment or income throughout the year. Small landholdings, seasonal agricultural activities, rising costs of cultivation and uncertain returns encourage many workers to look for alternative sources of income. As a result, people often migrate temporarily or permanently to cities and industrial regions. Migration is generally discussed from the perspective of the person who migrates. However, an equally important issue is the situation of those who remain in the village. When a household member migrates, responsibilities do not disappear; instead, they are often transferred to other family members. A woman may have to manage the household and agricultural activities in the absence of her husband, while grandparents may take responsibility for grandchildren when parents migrate.

Therefore, the study of migration should include both migrants and the population left behind. The present paper focuses on rural Uttar Pradesh and examines how migration affects household income, gender roles, family relationships, agricultural activities and the overall social structure of rural communities.

2. Objectives of the Study:

The main objectives of this study are:

1. To understand the major causes of migration from rural areas of Uttar Pradesh.

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2. To examine the characteristics of the population left behind by migrants.
3. To analyse the economic effects of migration on rural households.
4. To study the social and gender-related consequences of migration.
5. To suggest measures for improving the welfare of migrant families and rural communities.

3. Methodology:

The paper is based on secondary sources. Information has been drawn mainly from the Census of India, particularly its migration tables, along with government reports and existing studies on migration and rural livelihoods. The Census of India provides information on migration according to place of last residence, duration of residence, age, sex and reasons for migration. Such data are useful for understanding the broad patterns of population mobility in Uttar Pradesh. Since a new population Census has not yet provided a comparable comprehensive migration dataset after 2011, the 2011 Census remains an important statistical reference for analysing the structure of migration. The paper uses a descriptive and analytical approach to examine the relationship between migration and the well-being of people who remain in rural areas.

4. Migration from Rural Uttar Pradesh:

Migration from rural Uttar Pradesh takes several forms. Some people move permanently to cities, while others migrate for a few months and return to their villages after the agricultural season or when employment opportunities decline at their destination. This temporary and circular form of migration is particularly important among workers employed in construction, manufacturing, transport, domestic services, security and other informal occupations. Delhi and the National Capital Region, Haryana, Punjab, Maharashtra and Gujarat have historically attracted workers from Uttar Pradesh. At the same time, cities within Uttar Pradesh also attract rural workers. The distance and duration of migration vary according to the type of employment and the resources available to the household. Migration is often organised through social networks. A worker who has already migrated may help relatives or friends find accommodation and employment. Consequently, migration can gradually become a common livelihood strategy within a village or community. Migration also differs between households. Poor households may send one member to work elsewhere while maintaining the rest of the family in the village. Households with greater resources may migrate with their entire family. Thus, migration should not be treated as a uniform experience.

5. Major Causes of Rural Migration:

5.1 Lack of Local Employment

One of the major reasons for migration is the shortage of regular employment in villages. Agricultural work is often seasonal, and non-farm employment may be limited. Young workers therefore look towards towns and cities where they expect to find more regular employment.

5.2 Low Agricultural Income

Small and fragmented landholdings make it difficult for many rural households to depend entirely on agriculture. Rising input costs, uncertain rainfall and fluctuations in agricultural prices can further reduce household income. Migration provides an additional source of earnings.

5.3 Wage Differences: Urban and industrial areas generally offer higher wages than many rural occupations. Even when urban employment is physically demanding or insecure, the possibility of earning more can make migration attractive.

5.4 Family and Social Networks

Migration decisions are often influenced by relatives and friends who have already migrated. These networks reduce the risks associated with finding employment and accommodation in an unfamiliar place.

5.5 Education and Aspirations

Young population may migrate for higher education, training and professional opportunities. Migration can also be associated with aspirations for a better lifestyle and improved social status.

6. Who are the Left-Behind Population?

The left-behind population refers to family members who remain in the place of origin while one or more household members migrate. In rural Uttar Pradesh, this population commonly includes women, children and elderly parents. In households where men migrate for employment, women frequently remain responsible for household management. They may also become responsible for farming, livestock, childcare and elderly care. Children may remain with their mothers or grandparents, while older parents may depend on other family members for daily support. The size and composition of the left-behind population differ between households. In some cases, only one person migrates and the family continues to live together in the village. In other cases, several adult members migrate, leaving children and elderly people behind. This variation is important because the effects of migration depend heavily on who migrates, who remains and how frequently the migrant returns.

7. Economic Effects of Migration:

The most visible economic effect of migration is the flow of money from migrants to their families. These remittances can play an important role in rural household economies. Families may use remittances to purchase food and clothing, pay school fees, meet medical expenses, improve houses, repay debts or invest in agriculture. In some cases, remittances allow households to purchase livestock, agricultural equipment or start small businesses. Migration income can therefore reduce economic insecurity. A household that depends only on agriculture may face serious difficulties when crops fail. Income from a migrant worker provides an alternative source of support. However, migration does not always guarantee financial security. Many migrants work in informal occupations where employment is uncertain and wages may be low. A migrant may also have substantial living expenses at the destination. Consequently, the amount regularly sent home can vary.

The dependence of rural households on remittances can also create risks. If a migrant loses employment because of illness, an economic slowdown or another crisis, the family in the village may suddenly lose an important source of income.

8. Impact on Women:

The effect of migration on women is particularly significant. When husbands migrate, wives often become the main managers of the household. They may take decisions regarding food, children's education, agricultural activities and household expenditure. This increased responsibility can sometimes strengthen women's position within the household. Women may develop greater confidence in dealing with banks, schools, local government institutions and markets. Nevertheless, increased responsibility does not necessarily mean greater empowerment. Women may have to perform more unpaid work without gaining corresponding control over household income or property. They may have to combine domestic responsibilities with agricultural work and childcare.

Therefore, male migration can produce contradictory outcomes for women. It may provide greater decision-making opportunities while simultaneously increasing their workload.

9. Social Consequences:

Migration can transform traditional rural family relationships. A household may continue to have a house and agricultural land in the village even though some of its members spend most of their time elsewhere. Regular migration can also change consumption patterns. Families receiving remittances may invest in better houses, education, household goods and agricultural equipment. Migrants may bring new ideas and experiences from cities back to their villages. At the same time, prolonged separation can weaken everyday family interaction. Festivals, marriages and other social events may become important occasions for migrants to return home and maintain their connection with the village. Migration can therefore produce both continuity and change. Rural families remain connected to their villages while simultaneously becoming linked to urban labour markets.

10. Effects on Agriculture and Rural Economy:

Migration can have mixed consequences for agriculture. When working-age men leave, women and elderly people may have to manage farming activities. In some households, this can

increase the workload of women. On the other hand, remittances can provide money for seeds, fertilisers, irrigation, machinery and other agricultural inputs. Migrant income may therefore help maintain agricultural production even when household labour is reduced. Some households may also choose to rent out their land or reduce cultivation if there are insufficient workers. Thus, the agricultural consequences of migration depend on the household's landholding, financial resources and access to hired labour.

11. Problems Faced by Left-Behind Households:

Several problems are commonly associated with migration:

- Increased workload for women.
- Difficulty in managing childcare and elderly care.
- Dependence on irregular remittances.
- Reduced availability of family labour for agriculture.
- Difficulty accessing financial and government services.
- Greater vulnerability when migrants lose employment.
- Social isolation among elderly people.

These problems show that migration policy must consider the place of origin as well as the destination.

12. Policy Suggestions:

First, rural employment should be expanded. Development of small industries, Agro-processing, rural enterprises and service-sector activities can provide additional employment within villages and nearby towns.

Second, government welfare programmes should be accessible to migrant families regardless of where migrants work. Portability of food, healthcare and social security benefits is particularly important.

Third, women in migrant households should receive greater access to self-help groups, credit, skill development and agricultural extension services. Such programmes can reduce their economic dependence and strengthen their decision-making capacity.

Fourth, migrant households should be encouraged to use safe banking and remittance services. Financial literacy can help families save and invest remittance income more effectively.

Fifth, rural healthcare and educational facilities should be strengthened. Families should not have to depend entirely on migrant income to access basic public services.

Finally, migration statistics need to be regularly updated. Better data can help governments identify important migration corridors and understand the changing needs of migrant households.

Conclusion:

Migration has become an important part of the livelihood system of rural Uttar Pradesh. It allows households to diversify their income and access employment opportunities that may not exist in their villages. Remittances can improve living standards and help families meet expenses related to education, healthcare, housing and agriculture. However, the benefits of migration are accompanied by significant costs. The people who remain behind often carry additional responsibilities. Women may manage households and agricultural activities with limited support, children may experience prolonged parental absence, and elderly people may face loneliness and difficulties in accessing care. The experience of migration is therefore neither entirely positive nor entirely negative. Its effects depend on the type and duration of migration, the economic position of the household, the amount of remittances received and the availability of family and community support. For rural Uttar Pradesh, the objective should not simply be to prevent migration. Migration can be a legitimate means of improving livelihoods. Instead, government policy should reduce distress migration, create better rural employment opportunities, protect migrant workers and strengthen the social and economic security of those who remain behind.

A balanced approach that combines rural development, employment generation, women's empowerment, social protection and migrant welfare can ensure that migration contributes positively to the development of both villages and migrant families.

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Changing Power Structure and Empowerment of Marginalised Section of The Society (SC/STs and OBCs)

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Abstract

This paper tries to analyse the dynamics of empowerment of Scheduled Tribes (STs), Scheduled Castes (SCs) and other Backward Classes (OBCs) in post-colonial India with a focus on the structural transformation of social hierarchy and political power. The study examines the mechanisms that propelled the subaltern upward and their institutional constraints, using both the theory of sociological change and empirical evidence from national datasets (PLFS, AIDIS, IHDS, NFHS-5), official commissions (Xaxa committee, 1999, 2005, 2021, 2025; Rohini commission, 2023), and constitutional jurisprudence (State of Punjab v. Davinder Singh, 2024).

The results highlight a basic cleavage, but electoral mobilization and quotas have changed the presence of legislators and challenged the traditional upper-caste hegemony, without synchrony between political democratization and material structures. There is a caste-based concentration of asset ownership, corporate leadership and elite jobs in the private sector. At the same time, statutory protection of tribal lands is being undermined by state-directed extractivism and the degree of intratribal stratification makes the allocation of affirmative action benefits difficult. Presence to substantive equality needs to be a step forward from forma descriptive presence towards substantive equality, which involves an extension of diversity frameworks to private markets, an empirical disaggregation of sub-quotas through a comprehensive socio-economic caste census, and enforcement of ecological sovereignty in tribal village assemblies.

Keywords: Caste hierarchy, Affirmative action, Scheduled Castes, Scheduled Tribes, Other Backward Classes, Sub-categorization, Graded inequality, Political economy

Introduction

The evolution of modern India's social architecture represents one of the most complex democratic transitions in the post-colonial world. Historically structured by the institution of caste-a system conceptualized by B. R. Ambedkar (1936) as an ascending scale of reverence and a descending scale of contempt social power was maintained through ritual purity, coercive agrarian relations, and the monopolization of state literacy by elite social groups (Dirks, 2001; Jodhka, 2018). The post-independence era, marked by universal adult franchise, constitutional protections, and state-mandated affirmative action (Articles 15, 16, 330, and 332), disrupted these traditional hierarchies. The rise of intermediate peasant castes to regional political dominance (Srinivas, 1989), followed by the post-Mandal "Silent Revolution" (Jeffrey, 2005; Yadav, 1999), challenged upper-caste dominance across legislative assemblies and local governance institutions.

Despite significant political democratization, empirical evidence reveals an acute developmental paradox, formal political inclusion has decoupled from substantive socio-economic transformation (Deshpande, 2011; Thorat et al., 2012). While STs, SCs, and Other Backward Classes have occupied legislative and administrative offices, their material base remains constrained: Constitutional reservations remain confined to public sector employment, which accounts for less than 10% of total non-agricultural employment and continues to contract amid fiscal consolidation; The unregulated formal private sector continues to exhibit documented hiring penalties against Dalit and subaltern job-seekers (Thorat & Attewell, 2007); Scheduled Tribes face persistent land alienation and ecological displacement driven by

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resource extraction corridors (Xaxa Committee, 2021); Affirmative action benefits have concentrated among advanced sub-castes, generating severe intra-group inequality and political fragmentation (Government of India, 2023).

To interrogate these structural dynamics, this paper addresses four interlinked research questions: RQ1: How has the expansion of electoral competition and local decentralization (73rd/74th Amendments, PESA) altered the balance between descriptive and substantive political power for SCs, STs, and OBCs?; RQ2: What are the persistent empirical disparities in asset ownership, labor market returns, and intergenerational mobility across caste strata in the post-liberalization era? ; RQ3: In what ways do state-led extractivism and bureaucratic inertia circumvent statutory frameworks designed to safeguard tribal land autonomy and forest rights? ; RQ4: How do emerging faultlines-specifically intra-caste stratification, the "creamy layer" doctrine, and recent judicial mandates on sub-classification-reshape subaltern solidarity and redistributive policy?

This study employs an integrative empirical review and secondary data synthesis methodology, triangulating quantitative datasets, legal jurisprudence, and sociological literature to trace structural changes across social groups.

Theoretical and Conceptual Framework

The notion of caste and social stratification in India has shifted from the pre-Talcott Mountain approach of structural-functionalism explaining social position based on ritual considerations to a political-economy approach of social position based on power, material accumulation, and state mediation. Caste as it was defined in Early anthropological orthodoxy, such as Louis Dumont (1980), Homo Hierarchicus, was seen as only being determined by immutable religious division between "pure" and "impure," and between the with spiritual supremacy of the Brahmin and the secular power of the Kshatriya. In recent years, however, the theological determinism has been broken down, demonstrating that caste in post-colonial India operates as flexible, contested tool of political mobilization, monopolization of resources, and socio-economic control (Dirks, 2001; Jodhka, 2018). This paper, for analyzing the shifting power configuration of SCs, STs, and OBCs, constructs a synthesis of five theoretical pillars.

Graded Inequality and Subaltern Fragmentation

B. R. Ambedkar (1936) has introduced the term "graded inequality" to capture the essence of caste. Simple class binaries which are divided into the bourgeoisie and proletariat, or racial systems configured around bipolar exclusions, whereas, graded inequality arranges social groups based on two poles of exclusion, one of reverence and the other of contempt. Ambedkar showed that this architectural disarticulation does not allow the horizontal subaltern solidarity to develop, and all the intermediate layers gain in psychological and structural superiority by subjugating the layers below them, with the result that the subalterns are divided into various groups (Guru, 2011; Teltumbde, 2018). The problem of collective mobilization of marginalized communities is further complicated by internal divisions which is one reason why it is difficult to form a lasting coalition among SCs, STs, and the internally differentiated OBCs.

The Agrarian Power Axis: The Dominant Caste

M. N. Srinivas (1989) has coined the term "dominant caste," which provides a framework for the restructuring of rural power relations, which occurred after the intermediary land ownership system known as Zamindari abolition. Srinivas suggested that the region can be dominated by caste if the caste becomes the majority, if it is in charge of agricultural land holdings, and if it has the physical means of coercion as well as political influence. Land reforms in large stretches of rural India disproportionately favored middle class agrarian castes that are now mostly classified as OBCs like the Yadavs, Kurmis, Jats and Vokkaligas (Jha et al., 1991). This change, on one hand, had broken the traditional feudal power of upper caste Brahmins, Thakurs and Baniyas, but it had also created an antagonistic power axis at the village level between the upper class (agrarian) and the lower class (landless) agricultural laborers of SC groups (Jodhka, 2018).

The "Silent Revolution" and the Plebeianization of Politics

Christophe Jaffrelot (2003) has called the process of the democratization of the Indian polity the "Silent Revolution" in India. It refers to a structural shift from dominant to subaltern and backward castes in North India in the period between 1970's and 1990's in the realm of electoral and legislative politics. The democratic assertion went from clientelist cooptation to direct political agency with the implementation of the recommendations of the Mandal Commission and the failure of the Congress

"rainbow coalition" (Yadav, 1999). This "second democratic upsurge" plebeianized political institutions, allowing a non-noble identity to become a means for capturing state power and contesting administrative monopolies.

Descriptive vs. Substantive Representation

In order to determine if political participation leads to structural empowerment, the paper draws on Pitkin's (1967) and Phillips' (1998) conceptual separation of descriptive and substantive representation. While the participation of SCs and STs in legislative assemblies and local panchayats is guaranteed through constitutional provisions (Articles 330,332 and 243D), their substantive representation involves enacting policies that further the collective material interests of their social groups. Empirical evidence shows (Chattopadhyay & Duflo, 2004; Pande, 2003) that the mere presence of a descriptive MP is enough to affect the public goods allocation, but often times, marginalized MPs' transformative power is undermined by institutional barriers, party whip and patron-client networks.

Tribal Ecology, Autonomy, and Internal Colonialism

It is important to point out that the concept of Scheduled Tribes is a theoretical one, and does not require a caste-centric theoretical approach. This is also the view of the theorist Virginius Xaxa in his works (1999,2005) which draw on the idea of structural land alienation, cultural assimilation and the territorial dimensions of the concept of "internal colonialism." While SC is oppressed with the emphasis of social exclusion and manual labor exploitation in the village system, ST is oppressed with the emphasis of epistemic and physical displacement with state-led extractive economic activities and expansion of infrastructure projects onto their ancestral lands. The challenge of understanding ST empowerment requires a consideration of the conflict between constitutional protections (Fifth and Sixth Schedules, PESA 1996, FRA 2006) and the advancing political economy of natural resource expropriation.

Political Empowerment and State Restructuring

A major redistribution of political power in the post-colonial world was the shift from an elite-dominated colonial apparatus to a democratic mass-mobilized state. This restructuring has operated through two distinct mechanisms: top-down constitutional engineering via mandatory quotas, and bottom-up electoral mobilization driven by subaltern assertion.

The Mandal Cleavage and the Reconfiguration of Party Systems

The political ascendance of the OBCs gained momentum with the implementation of the recommendations of Mandal Commission in 1990, triggering what Yadav (1999) conceptualizes as the "Second Democratic Upsurge." This era signaled the collapse of the Single party dominance of Congress party-historically anchored in a clientelist coalition of upper-caste elites, Dalits, and religious minorities-and inaugurated a fragmented, competitive multi-party system across the Hindi heartland and southern states (Jaffrelot, 2003; Yadav, 1999). As Chandra (2003) demonstrates in her theory of "patronage democracy," the political mobilization of marginalized castes succeeded because voters leveraged ethnic counts to capture state resources. Political parties organized around backward-caste and Dalit identities (e.g., Samajwadi Party, Rashtriya Janata Dal, Bahujan Samaj Party) transformed caste into an electoral asset. In Uttar Pradesh and Bihar, the descriptive presence of OBCs and SCs in state legislative assemblies rose significantly:

- OBC Legislative Strength: The proportion of OBC Members of Legislative Assembly (MLAs) in northern states grew from less than 15% in the 1970s to over 30% by the late 1990s, altering the composition of regional assemblies (Jaffrelot, 2003).
- Executive Capture: The democratization of regional executive offices-exemplified by OBC and Dalit chief ministers-redirected the symbolic and discretionary powers of the state, altering bureaucratic recruitment and localized administration (Chandra, 2003; Jaffrelot, 2003).

Constitutional Quotas and Grassroots Institutional Devolution

Parallel to electoral politics, constitutional engineering altered political power through state-level and local affirmative action. Articles 330 and 332 of the Constitution mandated legislative seat reservations in the Lok Sabha and Vidhan Sabhas in proportion to SC and ST population shares. Subsequently, the 73rd and 74th Constitutional Amendments (1992) introduced Article 243D, extending mandatory quota protections to the third tier of governance i.e., Panchayati Raj Institutions (PRIs) and Urban Local Bodies (ULBs) for SCs, STs, and women.

The developmental impact of these mandates has been assessed in empirical economics:

1. State-Level Targeted Policy Influence: Pande (2003) exploited institutional variation in state-level reservation mandates between 1960 and 1992, finding that an increase in SC/ST legislative representation which is multidimentional directly increased targeted state redistribution while shifting fiscal allocations away from broad-based public goods like education. ST reservations expanded state spending on tribal development programs, while SC reservations increased public sector job quotas and targeted welfare transfers.
2. Micro-Level Resource Allocation: At the village level, Chattopadhyay and Duflo (2004) proved that affirmative action in local council leadership influences public investment. Marginalized sarpanches prioritize public goods that directly address community-specific needs (e.g., drinking water access, road connectivity in segregated hamlets).
3. Tribal Autonomy via PESA: In Scheduled Areas, the Panchayats (Extension to Scheduled Areas) Act (PESA), 1996 institutionalized participatory democracy by endowing the Gram Sabha with mandatory powers regarding land acquisition, minor forest produce ownership, and local dispute resolution.

Structural Bottlenecks and Limits of Substantive Empowerment

Despite electorally successful, empirical political economy identifies structural constraints that hinder descriptive representation from being realized as unconstrained substantive representation in the political arena.

The Joint-Electorate Incentive Trap and Party Gatekeeping

Unlike Ambedkar's separate electorates as proposed in the Poona Pact of 1932, the working of the legislative quotas is in a single-member, joint-electorate district. The representation of SCs in any Assembly constituency is usually less than 30% which means that legislators belonging to the SC communities have to seek majority in such constituencies from the non-Dalit and the dominant caste voters. Jensenius (2015) used more than 3,100 state assembly constituencies in a 30-year panel data analysis to determine that the 30 years of SC legislative quotas had no discernible effect on socio-economic development at the constituency level or on specific redistributions to the SCs. Party high command experts' substantive policy power through centralized selection of "moderate" candidates, and blocks radical "reformists" from being elected.

Non-Persistence and Electoral Fragility

Bhavnani (2017) used natural experiments to examine the persistence of electoral quotas after being phased out, investigating the temporal sustainability of electoral quotas. While gender quotas create persistent electoral viability, because SC candidates do not tend to do very well in unreserved and open constituencies. This underscores the fact that legislative integration is as much institutionalized as it is mandated by the state as a result of voter bias reduction in open contests.

Grassroots Hegemony and Coercive Backlash

On the local level, dominant agrarian castes often challenge formal institutional arrangements for power sharing by doing the following:

- Proxy Representation: The development of Sarpanch-Pati set-ups and powerful financial disbursing patrons from dominant castes appearing under the auspices of a nominally reserved Dalit/ST sarpanch.
- Spatial Exclusion & Coercive Violence: Physical exclusion in the village council halls, e.g., forcing Dalit panchayat presidents to sit on the floor and retaliatory violence or social boycotts if subaltern representatives exercise statutory authority over common property resources (Jodhka, 2018).
- Administrative Sabotage of PESA: Bureaucratic non-compliance, executive dilution of Gram Sabha consent, and unilateral state approvals of industrial mining corridors across Fifth Schedule territories (Xaxa Committee, 2021).

Socio-Economic Realities and Labour Markets

The presence of marginalised communities in the electoral sphere has been increased by the democratization of the electoral sphere, but their material situation continues to be constrained by structural inequalities in the ownership of assets, the division of labor and human capital accumulation. This difference has grown stronger since the shift from a state-governed planned economy to a market - driven economy. While political power has decentralized, economic capital, corporate control, and high-

value private employment remain concentrated among upper-caste networks (Deshpande, 2011; Thorat et al., 2012). Evaluating empirical datasets from the Periodic Labour Force Survey (PLFS), the India Human Development Survey (IHDS), the All-India Debt and Investment Survey (AIDIS), and the National Family Health Survey (NFHS-5) demonstrates how caste structures economic life.

Wealth Concentration, Physical Assets, and Land Polarization

Data from consecutive rounds of the All-India Debt and Investment Survey (AIDIS) and research on wealth inequality demonstrate that caste status is a consistent predictor of household asset portfolios in India (Anand & Thampi, 2021; Bharti, 2018).

1. Capital Polarization: Forward-caste households hold over 41.4% to 45% of total national wealth despite constituting roughly 20% of the population, whereas Scheduled Castes hold 7.3% to 8.2% of national wealth against a 16.6% population share, and Scheduled Tribes account for 3.4 to 3.8% of total assets against an 8.6% population share (Bharti, 2018).
2. Rural Landlessness: Over 55% of rural Scheduled Caste households are landless, surviving primarily as casual agricultural or non-farm day laborers (Deshpande, 2011; Rawal, 2008).
3. The Agrarian OBC Split: While agrarian OBCs (e.g., Jats, Yadavs, Kurmis, Marathas) consolidated landholdings following post-independence tenancy reforms, non-dominant Most Backward Classes (MBCs/EBCs) remain excluded from substantive landed capital, functioning within artisanal or informal wage niches with minimal wealth buffers (Jaffrelot, 2003).

Labour Market Segmentation, Wage Gaps, and Informalization

Data from the Periodic Labour Force Survey (PLFS, 2017–2023) highlights horizontal and vertical segregation across Indian labor markets. Formal, regular salaried employment with social security protections remains concentrated among upper castes, while SCs and STs are over-represented in vulnerable and informal occupations.

- Occupational Crowding: SC workers remain disproportionately clustered in sanitation, leatherwork, construction, and brick kilns, facing social and spatial barriers that block entry into retail or food handling (Deshpande, 2011; Thorat et al., 2012).
- The Unexplained Wage Penalty: Applying Blinder-Oaxaca econometric decompositions to National Sample Survey and PLFS data, Thorat and Attewell (2007) and Madheswaran (2006) demonstrate that 15% to 25% of the gross wage gap between Forward Castes and SC/ST workers cannot be explained by human capital endowments (education levels, age, vocational skills, or geographic location). This unexplained residual is a reflection of continuing discriminatory treatment in the labor market.

Private-Sector Discrimination and the Merit Discourse

However, formally, the private sector is free from diversity obligations as less than 10% of the non-agricultural workforce falls under the remit of constitutional reservations. Thorat and Attewell (2007) sent exactly the same resume to corporate recruiters with random names representing upper caste, Dalit, and Muslim candidates. Applicants having Dalit surname faces 0.67 times odds i.e., less likelihood of receiving an appositive call than applicants having upper-caste surnames with almost the same education. This caste penalty has been shown to hold in complimentary field experiments by Siddique (2011) for entry-level white collar hiring. The sociological study of corporate selection shows that the concept of 'merit' is regularly performed through subjective cultural markers like English fluency, family networks and cultural capital that create 'caste advantages' in the same name of 'corporate professionalism' (Deshpande & Newman, 2007; Upadhya, 2007).

Intergenerational Mobility and Multidimensional Deprivation

Caste shapes the intergenerational inheritance of capability and well-being beyond their current income. Asher, Novosad, and Rafkin (2024) calculate educational and occupational mobility at the administrative and micro-level for cohorts from 1950 to the late 1980s:

- Sticky Bottoms: The mobility of ST and SC up to the higher levels have been low over the past sixty years. Children of SC/ST parents who fall toward the bottom of educational distribution are likely to have a persistent mobility ceiling, that is, they will not be able to catch up with their upper-caste peers (Asher et al., 2024).

- The "Glass Floor": On the other hand, Forward-Caste children have a glass floor, which means they are unlikely to fall into lower socio-economic status deciles even if they do not make a successful investment in their education.

Health Capital Gradients: Evidence from NFHS-5 (2019–2021)

These economic constraints have a direct impact on health inequalities as reflected in the National Family Health Survey (IIPS & ICF, 2021):

- Under-Five Mortality Rate (U5MR): ST (50.3) and SC children (44.5) children still have the highest mortality rate as compared to non-SC/ST/OBC groups.
- Child Malnutrition and Stunting: Stunting children among SC and ST children are 39.5% and 41.5% respectively, due to undernutrition of mothers, poor sanitation in segregated residential colonies, and limited access to healthcare (IIPS & ICF, 2021; Rao et al., 2011).
- Maternal Health: Anaemia among the women age 15-49 is concentrated among ST (65.3%) and SC (58.9%) further aggravating the biological and social deprivation from one generation to another.

ST Ecology, Land Alienation, and Tribal Autonomy

The political economy of Scheduled Tribe (ST) marginalization diverges from the caste-based subordination experienced by SCs and OBCs. Exclusion of Dalits is based on ritual untouchability, spatial segmentation within the boundaries of the village, and Labour exploitation while the disposition of the Adivasi is based on territorial enclosure, ecological alienation, and state-directed extractivism (Baviskar, 1999; Guha, 2007; Xaxa, 1999). More than 80% of the mineral deposits of India, 7% of the dense forest cover and majority of riverine catchment basins are located in the tribal homelands of the country, which are mainly in the Central Indian forested plateau and North Eastern Hill tracts. This is a spatial convergence of natural resource wealth and socio-economic deprivation which is a manifestation of the "resource curse" that sees national capital accumulation occurring through the displacement of indigenous people (Xaxa, 2025; Sundar, 2019).

Development-Induced Displacement and Internal Colonialism

Many areas covered under the Fifth Schedule experienced large scale involuntary displacement in the wake of post-independence modernization project. The findings of the Virginius Xaxa Committee (2021) indicate that Scheduled Tribes make up 8.6% of the national population, while accounting for an estimated 40% to 50% of all internally displaced persons (IDPs) since 1947. This displacement carried out under the concept of 'eminent domain', as found in past colonial legislation and echoed in modern land acquisition laws. Capital-intensive open-cast mining, hydroelectric dams break customary property systems (chundavand or khuntkatti tenures) and make the agro-forestry practitioners a vulnerable migrant working in the informal urban sectors (Fernandes, 2008; Sundar, 2019). Rehabilitation policies continue to be underfunded and technocratic, not acknowledging the loss of community social capital, sacred landscapes, and ecological subsistence bases (Xaxa Committee, 2021).

Institutional Safeguards vs. Administrative Subversion: PESA and FRA

To correct past injustice and grant democratic autonomy to tribal communities, The Indian Parliament passed two legislative acts that were based on rights:

- Panchayats (Extension to Scheduled Areas) Act (PESA), 1996: Dealt with issues of land acquisition, customary dispute resolution, water bodies, and Minor Forest Produce (MFP) management, and empowered gram sabhas with statutory power over them.
- Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act (FRA), 2006: Recognized individual forest rights (IFR) for cultivation and habitation along with community forest rights (CFR) to protect, regenerate, and manage customary forest commons.

Even with a progressive set of laws, empirical studies find institutional resistance at the state executive machine. The Forest Department operating through colonial forestry laws and policies, has been systematically blocking the implementation of Community Forest Rights (CFR) as a democratic control mechanism in the forest neighborhoods and villages, as it perceives it is trespassing on the territorial forest sovereignty of the state.

State forest bureaucracies are more interested in Individual Forest Rights (which fragment common forest lands into small private plots) than in over 50% of community-level CFR claims in states like Chhattisgarh, Odisha, Madhya Pradesh, and Jharkhand (Ministry of Tribal Affairs [MoTA], 2022;

Xaxa Committee, 2021). Furthermore, statutory changes to environmental and mining laws have gradually made the mandatory Gram Sabha consent clauses into mere formality.

Constitutional Failure of the Fifth Schedule and Militarization

Another institutional failure is with the Fifth Schedule of the Constitution, which is governed. The State Governor is envisaged as an independent custodian of the welfare of the tribes in the Fifth Schedule of the Constitution, where Para 5(2) gives him/her plenary powers to prohibit or restrict the transfer of land of tribes to non-tribes and commercial corporations, as reinforced by the Supreme Court in the Samatha case, State of Andhra Pradesh, 1997. But as the Xaxa Committee (2021) has reported, Tribes Advisory Councils (TACs) are poorly consulted and Governors frequently serve as a funnel through which ruling-party policy is funneled instead of being subject to statutory review, thereby allowing for the clearance of resource-extraction corridors by corporations and projects. The state apparatus often times responds to Adivasi communities when they organize democratic resistance to protect their customary land rights, by criminalizing dissent and sending security forces against indigenous leadership (as seen in the Pathalgadi movement of Jharkhand, Guha, 2007; Sunder, 2016). The actual experience of ST empowerment is one of a fundamental contradiction: a wide-ranging constitutional vision that is attacked from below by the material needs of state-capital resource extraction.

Emerging Faultlines: Sub-Categorisation and the Creamy Layer

Over seven decades, affirmative action programs have evolved and the structural flaws of the way the SCs, STs and OBCs are treated as monolithic administrative groups have become a sharp legal-political issue. Far from being internally uniform, each broad constitutional category contains steep internal hierarchies of ritual status, literacy, economic capital, and geographic isolation. Consequently, affirmative action benefits particularly elite higher education admissions and Class-I/II public sector employment have disproportionately accrued to an advanced minority of sub-castes, generating intra-group rivalry and demands for internal sub-stratification (Deshpande, 2011).

Intra-OBC Stratification and the Justice Rohini Commission

The internal fragmentation of the Other Backward Classes demonstrates the skew in state resource distribution. Appointed under Article 340 of the Constitution in 2017, the Commission to Examine Sub-categorisation of OBCs (chaired by Justice G. Rohini) analyzed over 130,000 central government jobs and admissions under the 27% OBC quota across more than 2,600 individual castes on the Central List (Government of India, 2023). The Commission's draft findings revealed that nearly 97% of all jobs and higher education seats recruited under the Central OBC quota were captured by fewer than 25% of the enlisted sub-castes. Conversely, nearly 1,000 sub-castes primarily nomadic, semi-nomadic, and impoverished artisanal groups categorized as Extremely Backward Classes (EBCs) had virtually zero representation. This empirical reality has intensified demands to partition the 27% reservation into graded bands to prevent dominant agrarian OBCs from crowding out vulnerable sub-groups (Jaffrelot & Kalaiyarasan, 2019).

Judicial Realignment: State of Punjab v. Davinder Singh (2024)

The legal dispute over sub-classification within Scheduled Castes culminated in a constitutional shift. In E.V. Chinnaiah v. State of Andhra Pradesh (2005), a five-judge Constitution Bench had held that the Presidential List under Article 341 created a single, indivisible "homogenous class," rendering state-level sub-quotas for extremely marginalized Dalits (such as the Madigas in Andhra Pradesh/Telangana or the Valmikis and Mazhabi Sikhs in Punjab) unconstitutional. On August 1, 2024, a seven-judge Constitution Bench of the A majority of 6:1, the Supreme Court of India in State of Punjab and Others v. Davinder Singh and Others overruled E.V. Chinnaiah. The Court set precedent in important areas of law:

1. Permissibility of Sub-Classification: The majority held that Scheduled Castes do not constitute a homogeneous monolith. States have the legislative authority under Art 15(4) and 16(4) to sub-categorize SCs and STs for ensuring substantive equality provided that the classification is based on quantitative empirical findings of inadequate representation.
2. Prohibition of Total Exclusion: The Court mandated that sub-classification cannot result in the 100% reservation or total exclusion of any enumerated caste from the quota pool, safeguarding the integrity of Article 341.
3. The "Creamy Layer" Discourse in SC/STs: Four of the concurring justices observed that the principle of the "creamy layer" first institutionalized for OBCs in Indra Sawhney v. Union of

India (1992) ought to be extended to SCs and STs to prevent an entrenched bureaucratic elite from monopolizing affirmative action protections.

Political Fragmentation and Subaltern Contestation

These institutional developments have restructured electoral mobilization. Political parties increasingly engineer micro-coalitions by mobilizing Non-Dominant Dalits (e.g., Madigas, Arundhatiyars, Valmikis) and Most Backward Classes against politically dominant sub-castes (e.g., Malas, Jatavs, Yadavs) (Jogdand et al., 2016). While sub-categorization promises deeper distributive justice by disaggregating structural deprivation, it introduces acute political risks like it fractures subaltern solidarity, weakens collective anti-caste mobilization, and risks shifting structural focus away from the macro-contraction of public sector employment toward zero-sum intra-subaltern conflicts over an ever-shrinking pool of public jobs (Teltumbde, 2018).

Conclusion

The empirical and theoretical trajectory of post-independence India reveals a structural paradox i.e., democratic deepening without economic equalization. As detailed throughout this study, electoral competition, affirmative action mandates, and subaltern political assertion have altered the political architecture, enabling SCs, STs, and OBCs to capture legislative space and challenge traditional Brahminical and feudal hegemony (Jaffrelot, 2003; Yadav, 1999). This political democratization has, however, been met with the strong material obstacles. Due to the constitutional limitations of the public sector, during the process of transitioning from the publiv to a market-driven economy, private capital, plus elite corporate power and land assets have been retained on a caste basis (Deshpande, 2011; Thorat et al., 2012). At the same time, state-led resource extraction in Fifth Schedule areas has continued to push the tribes out of the area and limit statutory safeguards under PESA and the Forest Rights Act (Xaxa Committee, 2021).

Policy Interventions

In order to overcome descriptive inclusion to substantive equality, institutional reforms must tackle structural and market-based exclusions:

- Diversity Indices in the Private Sector: Set statutory diversity indices and public procurement preferences for companies meeting objective inclusion parameters, removing informal hiring cartels in corporate labor.
- Empirically Grounded Sub-Categorisation: Achieve Supreme Court's mandate in State of Punjab v. Davinder Singh (2024) by conducting nationwide socio-economic caste censuses, with the caste weights based on deprivation and not electoral patronage.
- Reintroduction of Ecological Sovereignty: Enforce the mandatory consent authority of the Gram Sabha under PESA and prioritize Community Forest Rights (CFR) title than state sanctioned industrial clearances in tribal belts.

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Experimental Validation and Performance Assessment of a Vertical U-Shaped Earth-Air Heat Exchanger in Wet Alluvial Soil

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Abstract

*Rapid urbanization, exponential population expansion, and compounding climate shifts have triggered an unprecedented inflation in global space-conditioning energy requirements. The resultant electrical peak load strain heavily penalizes fossil-fuel-dependent grids and amplifies environmental degradation. Earth-Air Heat Exchanger (EAHE) networks introduce a highly viable, low-enthalpy passive geothermal strategy by harnessing subsurface thermal mass stability. This research presents a broad theoretical framework, transient mathematical formulation, and field-scale experimental validation of a vertical U-shaped steel-pipe EAHE constructed within the specific young alluvial soil and shallow water-table environment of Sitamarhi, North Bihar, India. Operational boundary dynamics, including air mass flow velocity (*0.7 *m/s to* 4.1 *m/s) and geometric tube sizing, were parametrized to optimize sensible thermal dissipation and determine saturation inflection thresholds. Field observations recorded during intense pre-monsoon summer extremes (ambient air temperature inputs ranging between* 37.9°*C and* 41.5°*C) verified that the system delivers a continuous sensible temperature drop of* 10–14°*C. The conditioned air stream stabilizes near the constant unconfined subsoil sink benchmark (*25.3–26.9°*C) without displaying thermal degradation over extended runs.*

1. Introduction

1.1 The Global and National Energy Conundrum

Energy is fundamental to socio-economic development, industrial growth, and modernization. However, the global energy mix remains heavily dependent on depleting fossil fuels, whose combustion increases atmospheric greenhouse gases (GHGs), contributing to global warming, ozone depletion, acid rain, and ecological disruption. Rapid urban expansion has transformed natural green areas into dense built environments that trap solar radiation and intensify Urban Heat Islands (UHI). The United Nations estimates that 68% of the global population will live in urban areas by 2050, while the World Bank projects that 75% of Earth's land surface could be urbanized, causing severe habitat and ecosystem loss. Urbanization has already contributed to declining terrestrial species populations, with further acceleration expected. Microclimate studies show that city centers can experience dry-bulb temperatures up to 5 °C higher than nearby rural areas. This urban heating, combined with broader climate warming, has sharply increased mechanical air-conditioning demand. Space cooling is among the fastest-growing forms of building energy consumption, with thermal conditioning demand projected to triple by 2050. Refrigerants such as chlorofluorocarbons (CFCs) contribute to ozone depletion and global warming. If current trends persist, air conditioners could account for approximately 10% of global GHG emissions by 2050..

1.2 Space-Conditioning Stress in Agrarian and Rural Systems

While urban cooling demands impact grid stability, rural and semi-urban sectors face severe socio-economic impacts from the lack of low-cost space-conditioning technologies. Small and marginalized farmers are increasingly transitioning toward highly technical, value-intensive crops such as button mushroom (Agaricus bisporus) cultivation and controlled greenhouse polyhouses.

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2. Comprehensive Literature Review

2.1 Evolution of Low-Enthalpy Geothermal Systems

The core methodology of utilizing sub-surface earth masses as a thermal buffer dates back to antiquity. Archaeological records indicate that early engineering groups in the Persian and Roman Empires constructed elaborate underground tunnel systems. These pathways transferred ambient air across deep cellars to manage thermal conditions inside domestic structures and agricultural storage cavities.The mathematical and physical formalization of ground heat exchangers began with the historical work of Zoelly in 1912, who secured a pioneering patent utilizing sub-surface loops to assist mechanical heat pumps. This system framework was mathematically structured by Ingersoll and Plass in 1948. They formulated classical analytical solutions for ground-pipe heat transfer based on Kelvin's line source model, establishing the foundation for modern earth-tube research.

2.2 Global Parametric Studies and Research Gaps

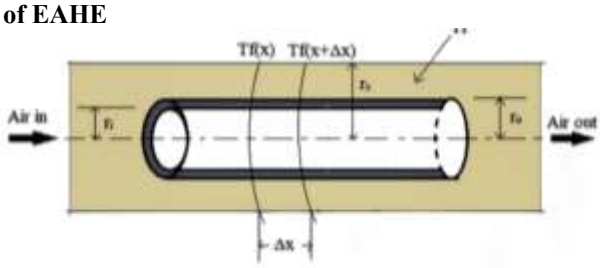
Over the past several decades, extensive research has explored the primary structural, operational, and climate parameters that govern Earth-Air Heat Exchanger performance. Geographical Location and Local Climatic Boundaries: Li et al. (2009) investigated EAHE networks across cold, northern climates in Harbin, China, highlighting that performance is heavily dependent on regional ground temperature dynamics. Fazlikhani et al. (2017) performed comparative modeling across hot-arid and cold zones in Iran. Their results proved that EAHE systems achieve highest efficiency in hot-arid climates. These configurations operate effectively for up to 294 days annually, delivering direct space energy savings of 50.1% to 63.6%. In humid tropical zones, Sanusi et al. (2013) validated temperature reductions of 6.9°C during hot dry cycles in Malaysia.

Subsurface Structural Depth Optimization: Radial thermal wave transmission from solar radiation drops exponentially with soil depth. Ground monitoring by Badescu (2007) verified that seasonal ground fluctuations fade out beyond a depth of 4 meters, where the subsurface layer reaches a steady state near the annual average air temperature index. Ahmed et al. (2016) executed comparative multi-depth evaluations at 0.6 m, 2.0 m, 4.0 m, and 8.0 m. Their work identified pipe installation depth as a dominant structural parameter affecting sensible cooling yields.Flow Velocity Parameters: The internal air flow velocity governs the contact timeline within the underground circuit. Bansal et al. (2009) noted that increasing internal velocity from 2.0 m/s to 5.0 m/s expands the inner convective heat transfer coefficient by a factor of 2.3. However, it simultaneously curtails fluid residency time by a factor of 2.5.

Despite this global literature base, a significant research gap persists. No comprehensive field-scale research has mapped EAHE system performance within the young, water-saturated alluvial soil plains. Prior research has mostly assumed dry, homogeneous sand or clay baselines. These models fail to represent configurations intersecting shallow, dynamically variable unconfined water tables. Alluvial loams demonstrate distinct thermal properties due to their balanced fractions of sand, silt, and clay. This composition enables high water-retention capacities, boosting ground thermal conductivity and preventing structural pipe corrosion or localized waterlogging. Furthermore, horizontal layouts demand large land footprints. This limitation requires a strict transition toward compact vertical U-shaped layouts tailored for dense agricultural and rural and urban residential settings.

3. Theoretical Framework & Mathematical Formulation

Design Parameters of EAHE

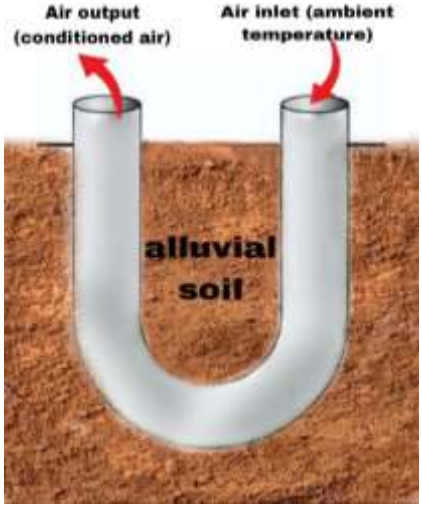


Cross-Section of Steel Pipe

Earth Air Heat Exchanger (EAHE) design shape is considered as vertical U shape. The pipe considered is of steel . Underground steel pipe has gone inside through wet alluvial soil as water table of Sitamarhi region is high being a wetland area**.**

3.1 Importance for EAHE Systems for wetland

Wet alluvial soil enhances heat exchange and stability, while optimized EAHE design improves efficiency, reliability, and minimizes cost and land use.



Vertical Underground EAHE In Alluvial Soil

Diameter of Steel pipe = .0254 m

Length of Pipe = 27 m

3.2 Numerical Calculation for Output Air Temperature of Earth Air Heat Transfer (EAHE)

3.2.1 The Nusselt number (Nu)

The Nusselt number (Nu) is a dimensionless quantity used in heat transfer calculations. It describes the ratio of convective to conductive heat transfer across a fluid boundary (like inside a pipe or over a surface).

$$Nu = \frac{hL}{k}$$

The Nusselt number (Nu) is a dimensionless quantity, where **h** represents the convective heat transfer coefficient (W/m²·K), **L** is the characteristic length, typically the pipe diameter for internal flow (m), and **k** denotes the thermal conductivity of the fluid (W/m·K).

Reynolds number (Re) is a dimensionless quantity used in fluid mechanics to predict flow patterns in different fluid flow situations. It indicates whether the flow is laminar, transitional, or turbulent

$$\text{Re} = \frac{\rho u D}{\mu} = \frac{u D}{\nu}$$

- ρ = Density of fluid (kg/m³)
- u = Flow velocity (m/s)
- D = Characteristic length (e.g., diameter of pipe) (m)
- μ = Dynamic viscosity (Pa·s or N·s/m²)
- $\nu = \frac{\mu}{\rho}$ = Kinematic viscosity (m²/s)

Interpretation

- Re < 2300: Laminar flow (smooth and orderly)
- 2300 < Re < 4000: Transitional flow

- Re > 4000: Turbulent flow (chaotic and mixed)

*D*ynamic viscosity of air for use in the Reynolds number, you can use the Sutherland's formula, which expresses how dynamic viscosity varies with temperature.

Sutherland's Formula

$$\boldsymbol{\mu(T) = \mu_0 \left(\frac{T}{T_0}\right)^{3/2} \cdot \frac{T_0 + C}{T + C}}$$

- $\mu(T)$ = dynamic viscosity at temperature T (Pa·s)
- μ_0 = reference viscosity at T_0
- T = temperature in Kelvin (K)
- T_0 = reference temperature (K)
- C = Sutherland's constant for air

Constants for Air:

- $\mu_0 = 1.716 \times 10^{-5}$ Pa·s
- $T_0 = 273.15$ K
- $C = 111$ K

3.2.2 Output temperature equation

Output temperature equation for an Earth-Air Heat Exchanger (EAHE), by using steady-state model of convective heat transfer between the air and the surrounding soil.The analysis assumes steady, incompressible air flow through the buried pipe, with constant fluid properties such as density and specific heat. Heat transfer is considered as one-dimensional radial conduction from the pipe to the surrounding soil, which is maintained at a constant ground temperature (T_s).The flow is also assumed to be fully developed thermally for simplicity.

Derivation:

We start with the differential energy balance over a small element dx of the pipe:

Energy loss (or gain) from the air:

$$\dot{Q} = -\dot{m}c_p \frac{dT}{dx}$$

Heat transfer from soil to air through the pipe wall

$$\dot{Q} = hP(T_s - T(x))$$

Where P is the inner perimeter of the pipe $P = \pi D$

Equating the two:

$$-\dot{m}c_p \frac{dT}{dx} = h\pi D(T_s - T(x))$$

$$\frac{dT}{dx} + \frac{h\pi D}{\dot{m}c_p}(T - T_s) = 0$$

$$\alpha = \frac{h\pi D}{\dot{m}c_p}$$

$$\frac{dT}{dx} + \alpha(T - T_s) = 0$$

This is a linear first-order ODE.

$$T(x) = T_s + (T_{in} - T_s)e^{-\alpha x}$$

Output temperature at length L:

$$T_{out} = T_s + (T_{in} - T_s)e^{-\alpha L}$$

Final Equation:

$$\boxed{T_{out} = T_s + (T_{in} - T_s)\exp\left(-\frac{h\pi DL}{\dot{m}c_p}\right)}$$

Interpretation:

- If h is high or flow is slow (low $\dot{m}$), more heat is transferred $T_{out} \rightarrow T_s$
- If pipe length L is long, more time for heat exchange greater approach to soil temperature.

3.3 Theoretical Calculation of Output Air Temperature

Reynolds number < 2300 (Laminar Flow)

Steel pipe Length = 56 feet = 17 m

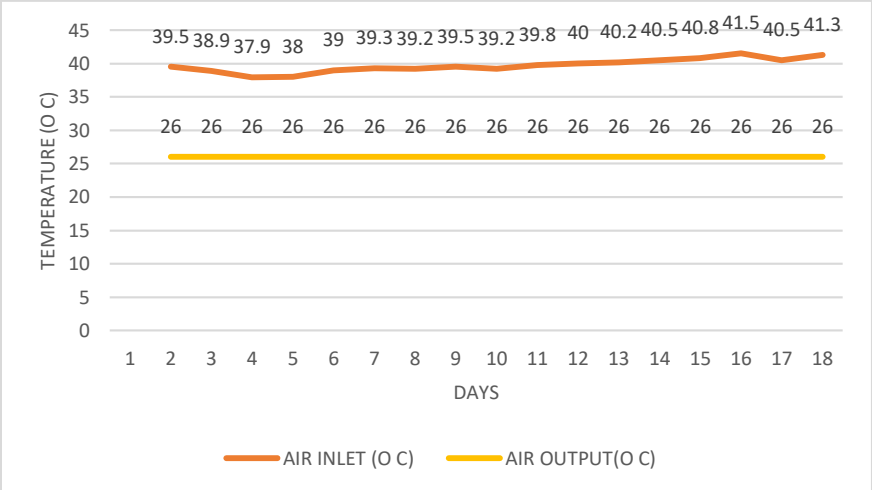
Diameter of pipe = .0254 m

T_s (Alluvial Soil Temperature) = 26 ºC

By using above mathematical equations theoretically output air temperature with respect to input (ambient) air temperature is calculated

DAYS	AIR VELOCITY (m/s)	AIR INLET (^{O} C)	AIR OUTPUT(^{O} C)
1	1.1	39.5	26
2	1	38.9	26
3	1.2	37.9	26
4	1.1	38	26
5	1.1	39	26
6	1	39.3	26
7	1.2	39.2	26
8	1	39.5	26
9	1.1	39.2	26
10	1.1	39.8	26
11	1.2	40	26
12	1	40.2	26
13	1.1	40.5	26
14	1	40.8	26
15	1.1	41.5	26
16	1.2	40.5	26
17	1	41.3	26

Output Air Temperature Calculation



Graphical Representation of output air temperature and input air temperature

4. Experimental Investigation

Earth-Air Heat Exchanger (EAHE) was designed at Sitamarhi, Bihar, considering the good thermal conductivity of alluvial soil. The high water table keeps the soil wet near the surface, enhancing heat exchange between soil and air.

4.1 Experimental set up

A borehole was prepared, and steel pipes were joined in a U-shape, ensuring no air or water leakage. The vertical U-shaped pipe was immersed in the ground for effective heat exchange. Air flows downward through one leg, exchanges heat with the cooler soil at depth, and returns through the other. This configuration utilizes deeper, stable ground temperatures, enhancing heat transfer compared with shallow horizontal systems.

Schematic representation of Earth Air Heat Exchanger



Vertical Underground EAHE In Alluvial Soil

Diameter of Steel pipe = .0254 Length of Pipe = 27 m

Ambient air was mechanically pumped through the buried steel pipe at varying velocities, exchanging heat with the surrounding soil. During summer, the cooler ground absorbed heat from the air, reducing its temperature. The conditioned air was then discharged through the outlet for ventilation and thermal comfort.

4.2 Experimental set up at the site

Anemometer is used for measuring wind velocity and air thermometer was used for measuring temperature of air going inside and coming out of the earth air heat exchanger after the set up. A bore is made where steel pipe in the vertical U shape is immersed in the alluvial soil.




Experimental set up preparation at ground




4.3 Readings of the experiment

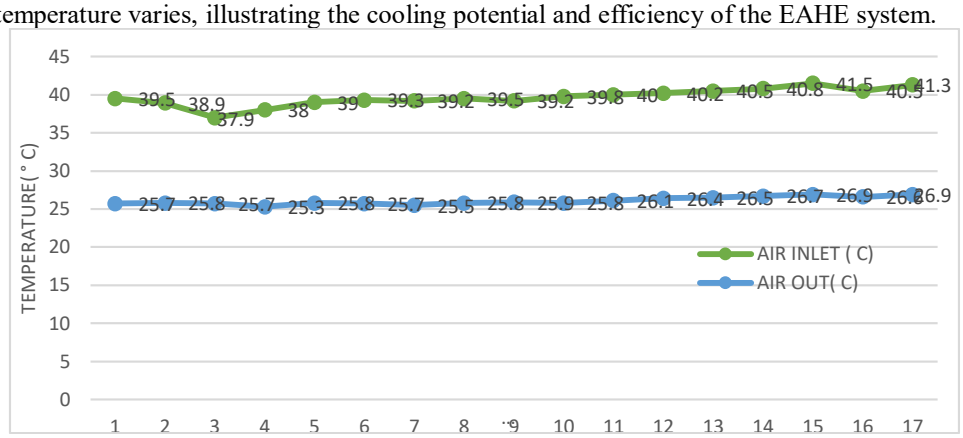
Output air temperature is very much near to the alluvial soil temperature of site. Data was taken in summer month of May June around 2.30 PM

DAYS	*AIR VELOCITY(m/s)*	*AIR INLET (^{O} C)*	*AIR OUTPUT(^{O} C)*
1	**1.1**	**39.5**	**25.7**
2	**1**	**38.9**	**25.8**
3	**1.2**	**37.9**	**25.7**
4	**1.1**	**38**	**25.3**
5	**1.1**	**39**	**25.8**
6	**1**	**39.3**	**25.7**
7	**1.2**	**39.2**	**25.5**
8	**1**	**39.5**	**25.8**
9	**1.1**	**39.2**	**25.9**
10	**1.1**	**39.8**	**25.8**
11	**1.2**	**40**	**26.1**
12	**1**	**40.2**	**26.4**
13	**1.1**	**40.5**	**26.5**
14	**1**	**40.8**	**26.7**
15	**1.1**	**41.5**	**26.9**
16	**1.2**	**40.5**	**26.6**
17	**1**	**41.3**	**26.9**

Conditioned Output Air Temperature(Degree Celsius)

4.4 Graphical representation of experimental data

This graph shows the output air temperature stabilizes near the soil temperature, while the input temperature varies, illustrating the cooling potential and efficiency of the EAHE system.



Variation of Output Air Temperature with Input Air Temperature in EAHE System

4.5 Conclusion

The present study experimentally investigated a vertical U-shaped Earth-Air Heat Exchanger (EAHE) installed in the wet alluvial soil of Sitamarhi, North Bihar, India. For inlet air temperatures of 37.9–41.5 °C and air velocities of 1.0–1.2 m/s, the EAHE reduced outlet air temperature to 25.3–26.9 °C, demonstrating effective passive cooling and bringing the conditioned air close to the soil temperature.

The vertical U-shaped configuration provides effective heat exchange with deeper, thermally stable soil while requiring limited surface area, making it suitable for rural and semi-urban applications. The results also indicate that wet alluvial soil offers favourable thermal conditions for EAHE operation.

Overall, the study demonstrates the feasibility of vertical EAHE systems as a low-energy, refrigerant-free cooling technology for buildings and agricultural applications in North Bihar. Future studies should examine seasonal operation, soil thermophysical properties, airflow and pipe geometry, thermal saturation and recovery, pumping power, and long-term economic performance.

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Effect of Fly Ash as a Particulate Pollutant on Growth and Yield of Oil-Yielding Crops

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Dr. Ravi Kr. Singh[**]

Abstract-

Fly ash is a major particulate pollutant released during coal combustion in thermal power plants and poses significant risks to agricultural ecosystems. Fine fly ash particles can travel through the atmosphere and deposit on crop leaves and soil, affecting plant growth, physiological processes, nutrient balance, and yield performance. The present study evaluates the effect of fly ash deposition on growth and productivity of important oil-yielding crops, namely safflower (Carthamus tinctorius L.), sesame (Sesamum indicum L.), and niger (Guizotia abyssinica L.), cultivated near a coal-based thermal power plant region in Bihar, India. The study focuses on assessing changes in growth attributes, photosynthetic activity, biomass production, reproductive development, seed yield, and oil content under different levels of fly ash exposure. Fly ash accumulation on leaf surfaces may reduce light absorption, restrict stomatal functioning, and disturb gaseous exchange, resulting in reduced photosynthetic efficiency and crop productivity. However, controlled application of fly ash may improve certain soil properties due to its mineral composition. The impact of fly ash depends on pollutant concentration, exposure duration, environmental conditions, and crop tolerance capacity. The study highlights the need for continuous monitoring, effective fly ash management, and development of pollution-tolerant crop varieties to ensure sustainable agricultural production in industrially affected regions.

Keywords: Fly ash; particulate pollution; oilseed crops; safflower; sesame; niger; photosynthesis; biomass; crop yield.

Environmental pollution has become a major global challenge due to rapid industrialization, urbanization, and increasing energy demands. Among different types of environmental pollution, air pollution caused by particulate matter is of particular concern because of its persistence, wide distribution, and direct interaction with living organisms. Industrial activities release large quantities of particulate pollutants into the atmosphere, which affect human health, natural ecosystems, soil properties, and agricultural productivity.

Coal-based thermal power plants are considered one of the major sources of particulate pollution. During the combustion of pulverized coal, large quantities of inorganic residues are produced, among which fly ash represents the fine particulate fraction carried by flue gases. Adriano, D. C. et. al., (1980) a modern pollution-control devices such as electrostatic precipitators help reduce emissions, a portion of fine fly ash particles escapes into the atmosphere and is transported by wind over surrounding agricultural landscapes.[1] These particles may settle on crop leaves, soil surfaces, and water bodies, causing ecological disturbances.

Fly ash is a heterogeneous mixture of mineral compounds mainly composed of silica (SiO_2), alumina (Al_2O_3), iron oxides (Fe_2O_3), calcium oxide (CaO), magnesium oxide (MgO), and other trace minerals. It may also contain potentially toxic elements such as arsenic, cadmium, chromium, lead, mercury, and nickel. (Carlson, C. L., & Adriano, D. C. (1993)[2] Gupta, A. K., & Sinha, S. (2008) The environmental impact of fly ash depends on its chemical composition, particle size, concentration, duration of exposure, climatic conditions, and sensitivity of plant species.[3]

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Plants growing near thermal power plants are continuously exposed to atmospheric fly ash deposition during their growth period. Gupta, S., et. al., (2002) leaves act as the primary surface for interaction between plants and airborne particulate pollutants.[4] Accumulation of fly ash particles on leaf surfaces may reduce sunlight penetration, block stomatal openings, interfere with carbon dioxide exchange, and alter transpiration processes. These changes can decrease photosynthetic efficiency, reduce carbohydrate production, and ultimately affect plant growth and productivity. In addition, fly ash deposited on soil may modify soil pH, nutrient availability, microbial activity, and heavy metal mobility.

Oil-yielding crops are important agricultural commodities because they provide edible oils, essential fatty acids, industrial raw materials, and nutritional products. India is one of the leading producers of oilseed crops, including safflower, sesame, mustard, soybean, groundnut, sunflower, and niger. Mishra, A., et. al., (2008) crop productivity in industrial regions is increasingly influenced by environmental stresses, including particulate pollution. Safflower (Carthamus tinctorius L.), sesame (Sesamum indicum L.), and niger (Guizotia abyssinica L.) are important oilseed crops cultivated under diverse agro-climatic conditions and may serve as suitable indicators for evaluating the effects of fly ash pollution.[5]

The response of plants to fly ash exposure is complex because fly ash contains both beneficial and harmful components. Pandey, J., & Kumar, R. (1996) at controlled concentrations, fly ash may improve soil fertility by supplying mineral nutrients and enhancing certain soil properties.[6] Pandey, J., & Kumar, R. (2004) was studied the excessive deposition can cause physiological stress, nutrient imbalance, oxidative damage, and reduction in crop yield. The degree of damage depends on plant species, growth stage, pollution intensity, and environmental conditions.[7]

Agricultural fields surrounding coal-based thermal power plants represent important areas for studying the interaction between industrial emissions and crop performance. In regions such as Bihar, where agricultural activities occur near thermal power generation facilities, continuous exposure to fly ash may influence crop growth, seed production, and oil accumulation. Therefore, understanding the effects of fly ash on oil-yielding crops is essential for developing sustainable agricultural practices.

The present study aims to evaluate the influence of fly ash as a particulate pollutant on the growth and yield performance of safflower, sesame, and niger cultivated near a coal-based thermal power plant. The study provides valuable information regarding crop responses to industrial pollution and supports strategies for pollution management, crop protection, and sustainable agricultural development in fly ash-affected regions.

Materials and Methods

Study Area- The present investigation is designed to study the effect of fly ash as a particulate pollutant on the growth and yield of oil-yielding crops cultivated around a coal-based thermal power plant region. The proposed study area is agricultural land surrounding NTPC Barh, Patna district, Bihar, India. The region represents a mixed industrial–agricultural ecosystem where crop cultivation occurs in close proximity to a major thermal power generation facility.

Objectives

i. To assess the effect of atmospheric fly ash deposition on agricultural crops cultivated near a coal-based thermal power plant.
ii. To evaluate the influence of fly ash pollution on growth characteristics of oil-yielding crops, including safflower (Carthamus tinctorius L.), sesame (Sesamum indicum L.), and niger (Guizotia abyssinica L.).
iii. To analyse changes in physiological parameters such as chlorophyll content, photosynthetic activity, and water relations under different levels of fly ash exposure.
iv. To determine the impact of fly ash on biomass production, reproductive development, seed yield, and oil content of selected oilseed crops.

v. To identify crop-specific tolerance responses and suggest suitable management strategies for agricultural sustainability in fly ash-affected regions.

Hypothesis: Atmospheric fly ash deposition significantly affects growth, physiological processes, biomass production, and yield characteristics of oil-yielding crops, and the magnitude of effects varies according to pollution intensity, distance from the emission source, and crop tolerance capacity.

Experimental Design and Sampling: Field sampling was conducted by selecting locations according to distance from the thermal power plant emission source. Three categories of sampling sites were considered:

(a). Highly polluted site (P_1): Approximately 1 km from the emission source with maximum fly ash influence.

(b). Moderately polluted site (P_2): Approximately 2 km from the emission source with intermediate pollution exposure.

(c). Control site (C): Located beyond 5 km from the emission source with minimum industrial influence.

Prasad, M. N. V. (2004) three economically important oil-yielding crops were selected for evaluation:-Safflower (Carthamus tinctorius L.), Sesame (Sesamum indicum L.) & Niger (Guizotia abyssinica L.).[8]

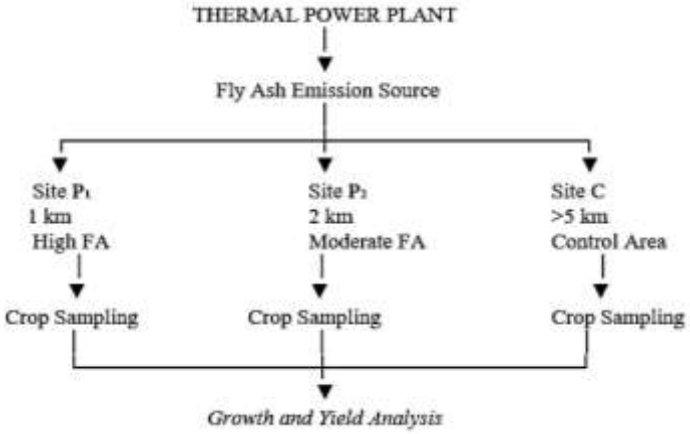
Plant samples were collected during vegetative, flowering, and maturity stages for analysis of growth, physiological, and yield parameters.

Fly Ash and Soil Analysis- Fly ash deposited on leaf surfaces was collected and estimated through gravimetric methods. The physical and chemical characteristics of fly ash, including pH, electrical conductivity, mineral composition, and heavy metal concentration, were analysed.

Soil samples from each experimental site were examined for Soil pH, Electrical conductivity, Organic carbon, Available nitrogen, phosphorus, and potassium & Heavy metal content including lead, cadmium, chromium, and nickel.

Growth and Physiological - Measurements the parameters recorded included to Plant height, Number of leaves, Leaf area, Number of branches, Root length and Fresh and dry biomass. while the physiological parameters analysed were Chlorophyll content, Photosynthetic activity, Stomatal behaviour, Relative water content & Antioxidant enzyme activity.

Yield and Oil Analysis- At maturity, yield parameters were recorded, including number of flowers/capitula/capsules, Seed number per plant, thousand seed weight, Total seed yield & Oil percentage and oil yield. Oil content was estimated using standard extraction procedures. Experimental Design and Sampling Strategy (Tripathi, A. K. et. al., 2004)[9]



Experimental Crops: Three economically important oil-yielding crops will be selected for investigation.

Table-1

Experimental Crops Used in the Study

Crop	Scientific Name	Family	Importance
Safflower	Carthamus tinctorius L.	Asteraceae	High-quality edible oil and drought tolerance
Sesame	Sesamum indicum L.	Pedaliaceae	Nutritionally valuable oil crop
Niger	Guizotia abyssinica L.	Asteraceae	Important minor oilseed crop

Results

The study revealed that fly ash deposition varied considerably among different sampling locations. The highest accumulation of particulate matter was observed at sites located closer to the thermal power plant, while the control site showed comparatively lower deposition levels. The distribution pattern indicated that distance from the emission source and atmospheric conditions strongly influenced fly ash accumulation.

Table-2

Experimental Crops Used in Study

Crop	Scientific Name	Family	Importance
Safflower	*Carthamus tinctorius* L.	Asteraceae	High-quality edible oil
Sesame	*Sesamum indicum* L.	Pedaliaceae	Nutritional oil crop
Niger	*Guizotia abyssinica* L.	Asteraceae	Important minor oilseed

Table-3

Fly Ash Exposure Levels

Treatment	Distance	Pollution Level	Colour Code
P_1	1 km	High Fly Ash	Red
P_2	2 km	Moderate Fly Ash	Orange
C	>5 km	Control	Green

Table-4

Effect of Fly Ash on Safflower Growth

Treatment	Plant Height (cm)	Leaf Area (cm^2)	Biomass (g $plant^{-1}$)
Control	96.5	245.3	38.6
P_2	82.4	198.6	30.2
P_1	68.7	145.8	22.4

Table-5

Effect of Fly Ash on Sesame Growth

Treatment	Plant Height (cm)	Leaves $Plant^{-1}$	Dry Weight (g)
Control	110.2	42	35.5
P_2	92.6	34	27.8
P_1	75.4	25	19.6

Table-6

Effect of Fly Ash on Niger Growth

Treatment	Plant Height (cm)	Flower Heads $Plant^{-1}$	Biomass (g)
Control	125.5	35	32.4
P_2	105.3	27	24.5
P_1	88.6	18	16.8

Table-7
Physiological Response of Crops Under Fly Ash Stress

Treatment	Chlorophyll (mg/g FW)	Photosynthesis	Stomatal Conductance
Control	2.85	High	High
P_2	2.20	Medium	Medium
P_1	1.65	Low	Low

Table-8
Yield Performance of Oilseed Crops

Crop	Treatment	Seed Yield (g plant^{-1})	Oil Content (%)
Safflower	Control	25.8	34.5
Safflower	P_2	19.6	30.2
Safflower	P_1	13.5	25.8
Sesame	Control	18.4	48.5
Sesame	P_2	14.2	43.6
Sesame	P_1	9.8	37.5
Niger	Control	16.7	38.4
Niger	P_2	12.5	33.7
Niger	P_1	8.4	29.2

Plants exposed to higher fly ash deposition showed visible changes in growth characteristics. Reduction in plant height, leaf area, leaf number, and total biomass was observed compared with plants growing under control conditions. The decrease in growth was mainly associated with reduced photosynthetic efficiency and interference with normal physiological processes.

Fly ash exposure significantly influenced physiological characteristics of crops. Higher particulate accumulation on leaves reduced chlorophyll content and photosynthetic activity. The deposited particles acted as a physical barrier, limiting light absorption and gaseous exchange through stomata. Increased stress conditions also influenced antioxidant defence mechanisms of plants.

Yield attributes of oilseed crops were affected by increasing fly ash exposure. Plants growing near the emission source showed reduced flowering, seed formation, seed weight, and oil accumulation compared with control plants. Among the studied crops, differences in tolerance responses were observed due to variations in plant structure and physiological adaptation mechanisms.

Discussion- The findings indicate that atmospheric fly ash deposition acts as an important environmental stress factor affecting agricultural productivity. The reduction in growth parameters may be explained by physical obstruction of leaf surfaces by particulate matter, which decreases light availability and restricts carbon dioxide exchange. Similar effects of industrial particulate pollution on plant physiology have been reported in earlier studies.

Fly ash contains several mineral elements that may have beneficial effects at lower concentrations. However, excessive deposition introduces stress through nutrient imbalance and possible accumulation of toxic elements. Heavy metals present in fly ash may interfere with enzymatic activities, nutrient uptake, and cellular metabolism.

Reduced chlorophyll content and photosynthetic activity under fly ash stress directly influence biomass production and yield formation. Since seed development depends on efficient photosynthetic carbon assimilation, stress during reproductive stages results in reduced seed yield and oil content.

The response of crops depends on species-specific tolerance mechanisms. Safflower and niger may show comparatively greater adaptability due to their stress tolerance characteristics, whereas sesame may be more sensitive during reproductive development. These differences highlight the importance of selecting suitable crop varieties for industrially affected regions.

Conclusion- Fly ash generated from coal-based thermal power plants significantly influences agricultural ecosystems through continuous atmospheric deposition. The present study demonstrates that higher fly ash exposure can negatively affect plant growth, physiological performance, biomass production, and yield characteristics of oil-yielding crops.

Although controlled utilization of fly ash may provide agricultural benefits, uncontrolled atmospheric deposition poses risks to crop productivity and environmental quality. Effective emission management, regular monitoring, and development of pollution-tolerant crop varieties are necessary to maintain sustainable agricultural production near industrial regions.

Recommendations- Continuous monitoring of fly ash deposition should be conducted in agricultural areas surrounding thermal power plants. Improved emission-control technologies should be implemented to reduce atmospheric particulate release. Green belts should be developed around industrial areas to minimize particulate movement. Crop varieties with higher tolerance to particulate pollution should be identified and promoted. Soil and crop testing should be conducted regularly to monitor heavy metal accumulation. Agricultural use of fly ash should be permitted only after proper chemical evaluation and risk assessment. Long-term research should focus on molecular mechanisms of fly ash tolerance and effects on food quality.

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Investigation of the Realism Movement in Short Stories of Persian and Urdu : An Overview and Comparative Study

Dr. Syed Mazahir Ali Rizvi*

Abstract

In the twentieth century, with the onset of novel writing and short story creation in the Persian and Urdu languages, literary movements and schools such as Realism, Social Realism, and Surrealism cast their shadow over the contemporary fictional literature of Iran and Pakistan. Modern Persian and Urdu prose encompasses a vast capital of novels and short stories, representing a rich treasure trove. Throughout various periods of growth and flourishing in fictional literature, the short story has been a pioneer of modern narrative art, particularly for contemporary writers. The present paper, while offering a concise examination of the Realism movement in short stories across both languages, takes a comparative look at their realistic literature. Indeed, various forms of realism in storytelling constitute one of the highly significant characteristics of contemporary Persian and Urdu fictional literature.

Keywords: Fictional Literature, Realism, Reality-depiction, Short Story, Social Realism, Literary School, Style.

1. Introduction

Human interest in stories, tales, fables, and legends—and even deep affection for them—constitutes an essential aspect of social existence. In truth, this subject reflects a facet of actual human life that man has embraced with logic, thought, and complete confidence. Humanity has derived countless lessons from the creation of stories. Among these narratives, courage, ambition, bravery, chivalry, generosity, affection, perseverance, and morality hold immense significance.

To relieve mental and physical fatigue, humans require an engaging pursuit capable of soothing their natural and superior emotions, temporarily offering self-forgetfulness, and keeping them insulated from the bitter events of their surrounding environment for at least a short duration.

The structural elements in short stories and novels share widespread commonalities universally: simple and complex plots, diverse, strong, and virtuous characters, expressive and dramatic delivery, main characters confronting innumerable dangers, detailed geographical descriptions, central figures caught in precarious situations, and broadly, narrative tropes of combat and banquet (razm and bazm). Furthermore, in the contemporary fictional literature of the Indian subcontinent and Pakistan, alongside these shared characteristics, a poetic atmosphere and aesthetic are prominently observed, in which stories exploring themes of reason, love, and romantic inclinations shine brightly.

2. Discussion and Analysis

In human cultural history, storytelling and story writing have flourished for centuries, and no nation or culture has remained untouched by them. During the pre-Islamic Jahiliyyah era, Arabs gathered after their evening meal to listen to storytellers. Upon conclusion, the narrator would receive a fee—typically consisting of dates—and the gathering would disperse. This tradition persisted across many nights. Early rudimentary forms of storytelling are also discernible in ancient civilizations. Ancient Egyptian, Chinese, Babylonian, Indian, and Greek civilizations possess immense antiquity, with Egyptian culture and civilization standing as the oldest among them. In Europe, such narratives were composed in the Romance language, giving rise to the terms 'romance' and 'novel'.

In Iranian fictional literature, the book Avesta holds paramount importance regarding early Persian narrative traditions. It serves fundamentally as the sacred scripture of Zoroastrians. Works

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such as Garshaspnama by Asadi Tusi, Drakht-i Asurig (The Babylonian Tree), Sindbad-nama, Kar-namag i Ardashir i Pabagan, and Jamasp Namak are rich in mythical narratives that hold immense historical weight in Persian literary heritage (Matin, p. 32).

Historical and social novels represent some of the most vital forms of Persian fictional literature. These modern novels began to take shape around the 1300s Solar Hijri calendar (1920s CE) (ibid, p. 14).

Realism in Modern Persian Short Fiction

Mohammad Ali Jamalzadeh (1892–1997 CE) was the pioneer of modern Persian short stories. With the publication of his landmark collection Yeki Bod Yeki Nabod (Once Upon a Time), he formally introduced the principles of literary realism and reality-based narrative to Persian readers. As the founding father of the modern Persian short story, Jamalzadeh successfully synthesized Western short story techniques and structures with traditional Persian storytelling styles. Yeki Bod Yeki Nabod stands as the origin and cornerstone of the realistic literary movement in Iran (Sabour, p. 324).

Consider the following excerpt from Jamalzadeh's short story Rajal-e Siyasi ('The Politician'):

"You ask how I became a politician and made a name for myself? You should know that four years ago I was a cotton fluffer, carding cotton for a living. Some days I made two thousand dinars, some days one toman. In the evening, I would bring home a man of Sangak bread and five seers of meat however I could. But my foolish wife would nag every night, saying: 'Hey, you keep fluffing cotton day in and day out, returning home with a cobweb beard, while our neighbor Haj Ali, who didn't have a penny to his name a year ago, has slowly become somebody with prestige! His wife says he'll become a Member of Parliament any day now with a salary of one hundred tomans, riding a bicycle and receiving a thousand respects! But you have to card cotton until you step into the grave... I wish you had a bit more backbone!'"

— Mohammad Ali Jamalzadeh, Yeki Bod Yeki Nabod, pp. 42–43

Sadegh Hedayat (1903–1951 CE) stands as the first Persian short story writer whose works reflect profound Western literary influence. Throughout Hedayat's oeuvre and short story collections, realistic techniques and perspectives are distinctly visible. While Hedayat left behind imaginative and surrealistic works, he is fundamentally recognized in contemporary Persian literature as a realistic author. Alongside realistic depictions, sharp critical satire permeates his prose—a technique especially evident in short stories such as Haji Morad, Davud the Hunchback, Abji Khanom, Morde-khorha (The Scavengers), Dash Akol, Talab-e Amorzesh (Seeking Absolution), Changal (The Claw), Mohallel (The Legalizer), The Woman Who Lost Her Husband, and Alaviyeh Khanom.

Hedayat realistically portrayed the authoritarian regime and prevailing superstitions of his contemporary society. His prose is descriptive and ushered in fundamental changes to modern narrative language. He introduced Modernism to Persian literature. Beyond his major novellas—namely The Blind Owl (his masterpiece) and Haji Aqa—he authored renowned short story collections including Three Drops of Blood (1932) and Buried Alive (1930).

Written in clear, accessible language, Hedayat's stories experimented with a wide array of styles ranging from Realism and Naturalism to Surrealistic fantasy. He broke new ground, introducing comprehensive literary patterns and techniques including linear and cyclical narrative structures across both realistic and surrealistic modes (Matin, p. 94).

Regarding his prose style, Hedayat possessed a unique ability where thought was immediately clothed in language upon inception—a trait connecting much of his work to Surrealist techniques. Meaning was never sacrificed for stylistic flourish. His prose was simple, eloquent, precise, and sturdy, rendering his style distinctly inimitable. Although he deeply influenced generations of young writers after him, his signature style remains unique (Sabour, p. 366).

A sample of Hedayat's prose in The Blind Owl:

"There are sores in life that slowly eat away at and wear down the soul in solitude like leprosy. These pains cannot be disclosed to anyone because people generally tend to regard these

unbelievable pains as rare and strange occurrences. If someone speaks or writes about them, people try to treat them with a skeptical and mocking smile based on current general beliefs, because humanity has not yet found a remedy for them. The only cure is forgetfulness through wine and artificial sleep via opium and narcotics. But alas, the effect of such drugs is temporary, and instead of soothing, it increases the severity of the pain after a while."

— Sadegh Hedayat, The Blind Owl (Sabour, p. 374)

Bozorg Alavi (1903–1996 CE) made invaluable contributions to contemporary Persian fiction following Hedayat. As one of the co-founders of modern Persian short fiction, Alavi was heavily influenced by Hedayat, a trait evident throughout his early work. Realist elements, particularly Social Realism, are central to Alavi's stories. The psychological influence of Sigmund Freud is also prominent in the works of both Hedayat and Alavi (Baharloo, p. 22).

In his debut short story collection Chamdan (The Suitcase), which carried Romantic undertones, Alavi was strongly influenced by Hedayat. However, with his masterpiece novel Cheshmayash (Her Eyes) and short stories like Gileh-mard in the collection Nameh-ha (Letters)—widely considered among the finest contemporary short stories—he developed his signature realistic style. Alavi pioneered the depiction of rural landscapes and prison environments in Iranian storytelling. His prose is recognized for its clarity, fluency, and robust realist texture (Sabour, p. 388).

Through his prison writings, Alavi introduced a new dimension of realism and pioneered Iranian prison literature, a movement that expanded significantly among subsequent writers. Social and political responsibility defined his short stories (Matin, p. 95).

A sample of Alavi's descriptive prose from Her Eyes:

"He had an elongated face, a high forehead, prominent cheekbones, a broken nose, large and penetrating eyes, arched eyebrows, a broad chin tapering at the end, and wore black horn-rimmed glasses. Whenever he stared at something, it was as if he wanted to extract the nerves and tendons from between the flesh, skin, and bones using his tweezers."

— Bozorg Alavi, Her Eyes, p. 1

Jalal Al-e Ahmad (1923–1969 CE) is another major figure in Persian fiction. Realism is deeply woven into his short story collections. As an advocate of progressive political and cultural ideas, Al-e Ahmad exercised immense influence over modern literary trends (Matin, p. 99).

Al-e Ahmad's realism was fundamentally Critical Realism. In exposing social realities, he focused on structural poverty and social inequality (Fadavi, p. 382). His prose was unadorned, direct, and closely aligned with conversational speech. He frequently omitted implied words or clauses, inviting readers to actively participate in completing the sentence's intent. His innovative, crisp prose style established him as an outstanding realist author (Sabour, p. 438).

In Modir-e Madreseh (The School Principal), Al-e Ahmad vividly captured the social realities of contemporary Iran, offering realistic character development and institutional critique.

A sample excerpt from The School Principal:

"When I walked through the door, I had a cigarette in my hand and felt too lazy to say hello. Just like that... and I tapped my cigarette into the shiny ashtray on his desk. Only my cigarette ash was extra—like spit on a clean-shaven face."

— Jalal Al-e Ahmad, Modir-e Madreseh, p. 10

Realism in Modern Urdu Short Fiction

The Realism movement in modern Urdu fictional literature originated at the dawn of the 20th century. This movement examined social life with rigorous detail, embedding pressing social themes into short story narratives. Realistic tendencies in Urdu fiction emerged partly as a reaction to the literary and educational movements of Aligarh and Anjuman-e-Punjab.

Premchand (1880–1936 CE), one of the greatest literary figures of the Indian subcontinent, was the pioneer and founder of the Realist school in Urdu fictional literature. His first short story collection, Soz-e-Watan (Sorrow of the Homeland), was published in 1908 and vibrantly reflected

patriotic themes. Poverty, rural hardship, and the struggles of peasants and common people formed the core subjects of his early 20th-century short stories.

As Urdu scholar Dr. Ibadat Brelvi notes: 'Premchand's short story writing is exceptionally valuable in both form and meaning. He was among the first writers to integrate diverse aspects of common life into short fiction, establishing and popularizing the Realist school—a completely revolutionary movement in Urdu literature' (Brelvi, p. 96).

The increasing social commentary in early Urdu realist fiction was directly tied to contemporary political shifts in the subcontinent. Premchand infused social realism with subtle satire and moral reformism, as seen in famous stories like Aah-e-Bakes (Sigh of the Helpless), Sirf Ek Aawaz (Only One Voice), and Namak Ka Daroga (The Salt Inspector). He stands as the first Urdu author to provide a fearless, objective, and empathetic depiction of social hardship.

Succeeding generations of writers—such as Sudarshan, Ali Abbas Husaini, and Aazam Kureyvi—continued Premchand's realist tradition. During the 1930s and 1940s, political and literary activism in the subcontinent reached its peak. In 1936, the birth of the Progressive Writers' Movement (Tarraqi Pasand) significantly bolstered realist fiction. The short story genre adopted diverse realist approaches, including simple realism, social realism, socialist and class realism, psychological and sexual realism, and symbolic realism (Ghezelbash, p. 151).

Prominent Urdu authors who fully embraced Realism as their guiding philosophy included Saadat Hasan Manto, Krishan Chander, Rajinder Singh Bedi, Ahmad Nadeem Qasmi, Ghulam Abbas, Ismat Chughtai, Devendra Satyarthi, Nakhab, Upendranath Ashk, Akhtar Orenvi, Akhtar Husain Raipuri, Hayatullah Ansari, Khadija Mastoor, Hajra Masroor, and Akhtar Ansari. Their works addressed social justice, economic hardship, alienation, cultural imperialism, populism, and social revolution.

Ghulam Abbas (1909–1982 CE) is another titan of Urdu short fiction who embedded realism deep into his work. Through diligent artistry, Abbas produced memorable short stories and novels, securing a revered position in Pakistani literature. His style is marked by subtle satire, targeting hypocrisy and social pretense. He frequently highlighted women's roles and struggles in society.

In short stories such as Ek Dardmand Dil, Lachak, Surkh Juloos, and Owtar, Abbas explored complex human psychology. His masterpiece collection Aanandi provides a meticulously detailed depiction of social reality, weaving together the lives of prostitutes, elites, street vendors, and social reformers. His collections—Aanandi, Jare Ki Chandni, Kan Ras, and Dhanak—reflect key social dynamics of the subcontinent.

Krishan Chander (1912–1977 CE) achieved extraordinary success as an Urdu short story writer. A dedicated humanist, his prose blended realistic narrative with imaginative warmth and occasional surrealistic elements. His realist approach bears strong affinity to Premchand's work. His debut collection, Tilism-e-Khayal (The Magic of Imagination), combined imaginative sweetness with reality, while stories like Ann Data (Giver of Grain) stand as masterpiece depictions of social inequality and economic crisis.

Following the partition and creation of Pakistan in 1947, widespread communal violence, mass migration, and trauma—known as Fasadaat—profoundly influenced short story writers in both India and Pakistan. Authors immortalized these tragic events through deeply realistic characters. Krishan Chander captured this era in collections such as Hum Wahshi Hain (We Are Savages), Kala Suraj (Black Sun), Maniya Bazar, Pani Ka Darakht (The Water Tree), and Mohabbat Ki Raat (Night of Love).

Saadat Hasan Manto (1912–1955 CE) stands among the world's greatest short story writers. Comparative analysis reveals striking structural and thematic similarities between the works of Sadegh Hedayat and Saadat Hasan Manto. Manto's prose is characterized by unadorned simplicity, poetic clarity, and uncompromising truthfulness.

Manto frequently focused on marginalized figures, particularly the lives and socio-economic struggles of prostitutes (Tawaifs). Masterpieces such as Hatek (Insult) and Kali Shalwar (Black

Pants) exemplify his fearless realism and naturalism. Manto depicted the plight of the oppressed with biting satire, denounced British colonialism, and explored inner human psychology with profound empathy. Heavily influenced by Russian and French realist masters, Manto remains a cornerstone of modern Urdu literature.

3. Conclusion

In the twentieth century, Persian and Urdu fictional literature drew from rich and diverse stylistic sources. The short story genre, in particular, became a primary vehicle for aesthetic expression, moral reflection, social reform, and political commentary. The Realism movement gained momentum in the 1930s and 1940s, evolving into the dominant paradigm for fiction writers in both Iran and the Indian subcontinent.

The defining shift of this era was the transition from classical, romantic, or mythic storytelling toward a modern, realistic depiction of characters, psychological states, and social structures. Writers across both Persian and Urdu meticulously portrayed socio-economic realities, class tensions, and human struggles. Their contributions produced enduring masterpieces across Realism, Social Realism, Critical Realism, and Surrealism, establishing a deep comparative and thematic harmony between modern Persian and Urdu short fiction.

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Modern Development of Ayodhya: An Archaeological Perspective

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Abstract :

Ayodhya is one of the oldest cultural and religious cities in India, with references found in Vedic literature, the Ramayana, the Puranas, and other historical sources. In contemporary India, the modern development of Ayodhya represents not only a major architectural and urban transformation but also an effort to preserve and reinterpret its rich cultural heritage through archaeological evidence. This study examines the modern reconstruction and development of Ayodhya from an archaeological perspective, highlighting the role of material remains, scientific investigations, and historical sources in understanding the city's ancient past and guiding its present transformation.

The research article is based on an analysis of archaeological excavation reports, particularly those of the Archaeological Survey of India (ASI), along with historical records, literary sources, and recent scholarly studies. The findings suggest that archaeological discoveries including structural remains, pillar bases, pottery, sculptures, inscriptions, and other artifacts have contributed significantly to reconstructing the historical sequence of settlement and cultural continuity in Ayodhya. Furthermore, the integration of archaeological heritage with modern urban planning, conservation strategies, and tourism infrastructure has strengthened Ayodhya's position as a prominent religious, cultural, and heritage destination.

The study concludes that the modern development of Ayodhya extends beyond physical infrastructure and reflects a broader commitment to heritage conservation, archaeological research, and the preservation of India's historical legacy. It underscores the importance of archaeology in informing sustainable development while maintaining the authenticity and cultural significance of one of India's most revered historical cities.

Keywords: Ayodhya, Modern Development, Archaeology, Archaeological Survey of India (ASI), Cultural Heritage, Excavation, Heritage Conservation, Urban Development.

1. Introduction

Ayodhya, situated on the banks of the Sarayu River in Uttar Pradesh, India, is one of the country's most historically significant urban centres. Beyond its religious importance, the city represents an important archaeological landscape where evidence from multiple historical periods has been documented through systematic excavation and scientific investigation. Archaeology provides an objective framework for understanding Ayodhya's historical development by relying upon material culture rather than literary or religious narratives alone (Cuningham & Young, 2015).

The archaeological importance of Ayodhya extends beyond India because it illustrates broader questions concerning urbanization in the Gangetic plains, the development of early historic kingdoms, the interaction between archaeology and textual traditions, and the challenges of preserving archaeological heritage within rapidly expanding modern cities. The city's archaeological record has therefore become central to discussions of cultural heritage management, conservation planning, and sustainable urban development. Excavations have revealed multiple cultural layers corresponding to different historical periods, indicating that Ayodhya experienced continuous occupation rather than representing a single-period settlement (Lal, 2008).

Recent redevelopment initiatives have dramatically altered Ayodhya's physical landscape. Large-scale infrastructure projects—including expanded highways, riverfront development, airports, railway modernization, museums, public spaces, and the construction of the Ram Mandir—have transformed the

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city into an international pilgrimage destination. These developments present opportunities for economic growth while simultaneously posing challenges for archaeological conservation because extensive construction activities can potentially affect buried cultural deposits (UNESCO, 2011).

This review examines the archaeological evidence associated with Ayodhya's historical development while critically assessing the relationship between archaeology and contemporary urban transformation. The paper emphasizes evidence-based archaeological interpretation rather than theological or political debates, thereby contributing to an objective understanding of Ayodhya's past and present.

2. Historical Background of Ayodhya

Ayodhya possesses one of the longest documented historical traditions among South Asian cities. Literary references occur in ancient Sanskrit texts, Buddhist literature, Jain scriptures, and later historical records. However, archaeological research distinguishes between literary traditions and empirically verifiable material evidence.

Ancient literary sources such as the *Valmiki Ramayana* describe Ayodhya as the capital of the Kosala Kingdom under King Dasharatha and later Lord Rama. Although these texts remain culturally significant, archaeologists evaluate historical claims primarily through stratigraphic excavation, radiometric dating where applicable, ceramic typology, numismatics, inscriptions, and architectural analysis (Bakker, 1986).

Ayodhya also occupied an important position within Buddhist and Jain traditions. Buddhist texts mention Saketa—often identified with Ayodhya—as an important settlement visited by Buddhist monks. Chinese pilgrims such as Faxian and Xuanzang described monasteries, temples, and educational institutions in the region during the Gupta and post-Gupta periods, indicating religious diversity and continued urban occupation (Beal, 1884).

During the Gupta Empire (4th–6th centuries CE) Ayodhya experienced renewed political and religious importance. Archaeological evidence from this period includes sculptural fragments, temple remains, inscriptions and artistic materials characteristic of Gupta craftsmanship. The Gupta era is widely regarded as one of significant cultural and architectural development in northern India and Ayodhya appears to have participated in these broader historical processes (Singh, 2008).

3. Archaeological Investigations in Ayodhya

Early Archaeological Explorations

Scientific archaeological investigation in Ayodhya began during the nineteenth century under the British administration. Alexander Cunningham, the first Director-General of the Archaeological Survey of India, conducted surveys that documented ancient mounds, sculptures, inscriptions and architectural remains throughout northern India. Although excavation techniques at that time lacked modern scientific precision, Cunningham's work established the archaeological significance of Ayodhya and encouraged later systematic investigations (Cunningham, 1871).

Systematic Excavations by B. B. Lal

A major advancement occurred during the 1970s when archaeologist B. B. Lal directed excavations under the Archaeological Survey of India as part of the "Archaeology of the Ramayana Sites" project (Lal, 1977).

The excavations identified multiple cultural phases extending from the Northern Black Polished Ware period through medieval times. Important discoveries included:- Brick structural remains, Ring wells, Terracotta figurines, Pottery assemblages, Iron implements, Stone architectural fragments, Beads and ornaments.

These findings suggested prolonged occupation and urban development across several historical periods. Lal argued that Ayodhya possessed continuous archaeological evidence extending from the early historic period into the medieval era (Lal, 2008).

Archaeological Survey of India Excavations (2003)

One of the most extensive archaeological investigations in Ayodhya occurred in 2003 when the Archaeological Survey of India conducted excavations under the direction of the Allahabad High

Court. The objective was to document the archaeological sequence beneath the disputed site using standardized scientific procedures (ASI, 2003).

The ASI reported evidence of successive occupational levels extending across several centuries. Significant findings included:- Pillar bases, Brick walls, Stone architectural fragments, Terracotta sculptures, Decorative carvings, Pottery from multiple cultural periods, Lime floors, Circular shrines, Drainage systems, Animal bones, Iron objects, Copper coins, Glass beads.etc…

The report interpreted these findings as indicating the existence of a substantial pre-existing non-Islamic public structure beneath later levels (ASI, 2003).

4. Scientific Methods Used in Ayodhya Archaeology

Archaeological interpretation is fundamentally based on scientific methods that ensure the systematic recovery, documentation, and analysis of material remains. In Ayodhya, investigations have relied on a combination of traditional excavation techniques and modern archaeological sciences to reconstruct the city's occupational history. (Renfrew & Bahn, 2020).

Stratigraphic Excavation

Stratigraphy is one of the most important principles in archaeology. It is based on the Law of Superposition, which states that, under normal conditions, deeper layers are older than those above them (Harris, 1989).

The 2003 ASI excavation employed detailed stratigraphic recording, with each layer assigned a unique context number. This approach helped identify changes in construction techniques, floor levels, pottery assemblages, and architectural modifications over time (ASI, 2003).

Ceramic Analysis

Pottery remains are among the most valuable archaeological indicators because ceramic styles evolve over time and can therefore be used for dating archaeological contexts.

The presence of Northern Black Polished Ware, generally dated between the sixth and second centuries BCE, indicates that Ayodhya was an important urban settlement during the early historic period (Singh, 2008).

Architectural Analysis

Architectural remains recovered from Ayodhya include: Brick foundations, Stone pillars, Lime floors, Drainage systems, Staircases, Structural walls, Carved architectural fragments

These remains help archaeologists reconstruct ancient building techniques, public architecture, and urban planning. Comparative analysis with structures from other early historic and medieval sites enables researchers to identify architectural traditions associated with different historical periods (Michell, 1988).

Numismatic Studies

Coins recovered during excavations contribute significantly to archaeological dating. Ayodhya has yielded:- Punch-marked coins, Kushana coins, Gupta coins, Medieval copper coins.

Numismatic evidence provides chronological markers while also illustrating political authority, economic exchange and regional trade networks. The circulation of coins from different dynasties indicates Ayodhya's continued integration into wider economic systems across successive historical periods (Allchin & Erdosy, 1995).

Terracotta and Sculptural Analysis

Excavations at Ayodhya have recovered:- Human figurines, Animal figurines, Toys, Ornaments, Ritual objects, Decorative plaques.

These objects reveal aspects of domestic culture, religious practices, artistic traditions and local craftsmanship (Lal, 2008).

5. Modern Development of Ayodhya

The twenty-first century has witnessed unprecedented urban transformation in Ayodhya. Following the 2019 judgment of the Supreme Court of India, the city entered a new phase of infrastructure expansion, heritage conservation, tourism development and religious pilgrimage.

Although these initiatives have significantly enhanced connectivity and public facilities, they also require careful archaeological oversight to protect buried cultural remains.

Construction of the Ram Mandir

The construction of the Ram Mandir represents one of the most significant recent developments in Ayodhya. Beyond its religious importance, the project has influenced urban planning, transportation, tourism and economic development.

From an archaeological perspective, the project attracted attention because of the site's historical significance and previous excavations. Documentation of archaeological contexts before major construction emphasized the importance of preserving evidence and maintaining detailed records of structural remains (ASI, 2003).

The temple complex has also stimulated broader discussions regarding the relationship between archaeology, cultural heritage and public memory.

Expansion of Urban Infrastructure

Modern Ayodhya has undergone extensive infrastructural improvements, including:- Expansion of national highways, Railway station modernization, Development of Maharishi Valmiki International Airport, New bridges and road networks, public transport improvements, Riverfront beautification, Improved drainage and sanitation systems

These projects are intended to accommodate the increasing number of pilgrims and tourists while improving the quality of life for residents. However, infrastructure development in historically significant cities necessitates archaeological impact assessments to ensure that construction activities do not damage subsurface cultural deposits (UNESCO, 2011).

Heritage Conservation

Heritage conservation has become an integral component of Ayodhya's redevelopment strategy. Conservation efforts include: - Restoration of historical monuments, Protection of archaeological sites, Documentation of heritage structures, Adaptive reuse of historical buildings, Landscape conservation, Preservation of cultural routes

These initiatives reflect international principles of heritage management, which emphasize the conservation of both tangible and intangible cultural heritage.

Museum Development

Museums play an essential role in preserving and interpreting archaeological discoveries. Plans for museum expansion in Ayodhya aim to display: - Excavated artifacts, Sculptural remains, ancient inscriptions, Terracotta collections, Coins, Digital reconstructions, Interactive heritage exhibits

Modern museums also contribute to public archaeology by communicating scientific findings to wider audiences and promoting awareness of cultural heritage.

Tourism and Economic Development

Ayodhya's redevelopment has substantially increased tourism. Heritage tourism generates employment in sectors such as: - Hospitality, Transportation, Traditional crafts, Cultural performances, Local markets, Heritage interpretation

Economic benefits can provide additional resources for archaeological conservation. Nevertheless, excessive tourism may threaten fragile heritage sites through increased foot traffic, pollution, and commercialization. Sustainable tourism planning therefore remains essential (UNESCO, 2011).

6. Future Directions

Future archaeological research in Ayodhya should adopt advanced scientific methods while strengthening conservation and public engagement.

Preventive Archaeology

Rather than responding after archaeological discoveries occur, future urban development should incorporate preventive archaeology, whereby archaeological assessments become mandatory before major construction projects. Heritage Impact Assessment, Trial trenching. Geophysical surveys, Rescue excavations where necessary, Continuous archaeological monitoring.

International Collaboration

Collaboration with international research institutions can strengthen archaeological research through: - Joint excavations, oratory analyses, Conservation training, Digital documentation, Heritage management research, Academic exchange programs.

Such partnerships encourage methodological innovation while promoting global recognition of India's archaeological heritage.

8. Review of Literature

Sharma, Samdish & Behera, Manas Ranjan (2025) Sharma and Behera developed the Ayodhya Development Transformation Index (ADTI) to assess the city's rapid transformation after the construction of the Ram Temple. Their multidimensional framework integrates economic growth, social development, cultural heritage, spirituality, and urban infrastructure. The authors argued that Ayodhya's development should not be evaluated solely through economic indicators but also through cultural sustainability and heritage preservation. The study demonstrates that archaeological heritage has become a significant component of Ayodhya's urban identity and tourism economy.

Rachel A. Varghese (2024) Varghese examined the role of archaeology in the Ayodhya dispute by analyzing the Archaeological Survey of India's excavations and their interpretation in judicial proceedings. The study introduced the concept of a "hybrid episteme," illustrating how archaeological knowledge, legal reasoning, and political narratives intersected in the Ayodhya case. It highlights the growing importance of public archaeology and heritage politics in contemporary India.

B. B. Lal (2024) B. B. Lal revisited the archaeological history of Ayodhya, examining material remains in conjunction with literary traditions. The research reaffirmed the significance of archaeological excavations in reconstructing Ayodhya's historical evolution from the early historic period through the medieval era. The author highlighted the continuity of settlement and religious activity reflected in the archaeological record.

Cunningham, Alexander (1863) Alexander Cunningham, the first Director-General of the Archaeological Survey of India, conducted the earliest systematic archaeological survey of Ayodhya. He identified ancient mounds, examined Chinese pilgrim accounts, and attempted to correlate historical Ayodhya (Saketa) with archaeological remains. His work established the foundation for subsequent archaeological investigations in Ayodhya.

9. Objecive of the study

1. To examine the historical and archaeological significance of Ayodhya and its role in the evolution of Indian civilization.
2. To analyze the major archaeological discoveries in Ayodhya and assess their contribution to understanding the city's historical and cultural development.
3. To evaluate the impact of recent urban development projects (such as the Ram Mandir complex, Maharishi Valmiki International Airport, road widening, riverfront development, museums, and tourism infrastructure) on Ayodhya's archaeological heritage.
4. To assess the role of the Archaeological Survey of India (ASI) and other heritage organizations in the conservation, preservation, and management of archaeological sites in Ayodhya.
5. To examine the integration of archaeological heritage with modern urban planning and sustainable development strategies.

10. Hypothesis

1. Modern urban development has no significant impact on the preservation of Ayodhya's archaeological heritage.
2. There is no significant relationship between archaeological conservation and sustainable urban development in Ayodhya.
3. Archaeological heritage does not significantly contribute to the growth of cultural and religious tourism in Ayodhya.

4. The conservation initiatives undertaken by the Archaeological Survey of India and other heritage agencies have no significant influence on the protection of archaeological sites in Ayodhya.

11. Conclusion

Archaeological investigations conducted over more than a century have demonstrated that the city possesses a long and continuous occupational history extending from the early historic period through medieval and modern times. (Lal,2008; ASI, 2003).

The modern redevelopment of Ayodhya has transformed the city into one of India's most significant heritage and pilgrimage destinations. Infrastructure expansion, transportation improvements, museum development, riverfront enhancement, and heritage conservation projects have strengthened the city's economic and cultural profile. At the same time, rapid urban growth underscores the need to integrate archaeological research into planning processes to ensure that development does not compromise irreplaceable cultural resources.

From an archaeological perspective, Ayodhya illustrates the importance of evidence-based historical reconstruction. Scientific methods including stratigraphy, ceramic analysis, architectural study, numismatics, and digital documentation enable researchers to reconstruct the city's complex developmental sequence while minimizing subjective interpretation. Archaeology also contributes to heritage management by informing conservation strategies, museum interpretation, tourism planning, and public education.

Future research should prioritize multidisciplinary collaboration, preventive archaeology, digital heritage documentation, community participation, and sustainable urban planning. These approaches will help preserve Ayodhya's archaeological legacy while supporting its continued development as a living heritage city. Ultimately, Ayodhya demonstrates that archaeological evidence and responsible heritage management can work together to depend historical understanding, protect cultural resources, and guide sustainable development for future generations.

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Governance of Pharmaceutical Quality in India: Administrative Challenges in Controlling Substandard, Spurious and Falsified Medicines

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Abstract

Pharmaceutical quality is often treated as a technical question of manufacturing compliance or a criminal problem of falsified medicines. In India, however, quality assurance also depends on the administrative capacity through which standards are implemented, manufacturing premises inspected, medicines sampled and tested, information shared across jurisdictions, and violations corrected. This paper examines pharmaceutical-quality governance in India through the framework of regulatory capacity. Drawing on qualitative documentary and secondary-data analysis, it combines peer-reviewed research with legislation, Central Drugs Standard Control Organization (CDSCO) documents, government reports, parliamentary material and World Health Organization publications. The analysis distinguishes substandard and falsified medicines from the Indian regulatory categories of Not of Standard Quality (NSQ) and spurious drugs. It argues that a central governance challenge is not decentralization itself, but whether India's decentralized regulatory structure possesses sufficiently comparable regulatory, analytical, coordination and delivery capacities to produce consistent outcomes. Recent reforms—including revised Schedule M requirements, risk-based inspections, strengthened sampling guidelines, laboratory expansion, digital regulatory systems, state-level benchmarking and pharmaceutical traceability—indicate movement toward more preventive and risk-oriented regulation. Their effectiveness, however, cannot yet be inferred from inspection counts, enforcement orders or new digital platforms alone. Strengthening pharmaceutical quality requires comparable state capacity, interoperable Centre–State information systems, differentiated enforcement, measurable recall performance and the complementary use of risk-based and representative surveillance.

Keywords: pharmaceutical quality; drug regulation; regulatory capacity; CDSCO; substandard medicines

1. Introduction

India is a major producer and supplier of pharmaceutical products, particularly generic medicines. The scale of this industry makes pharmaceutical-quality regulation more than a conventional matter of industrial compliance. Quality failures may affect treatment outcomes, antimicrobial resistance, public procurement, confidence in health institutions and India's reputation as a medicine supplier. Recent scholarship has consequently placed increasing attention on the relationship between regulatory standards, manufacturing quality and confidence in Indian pharmaceutical products (Ali & Sinha, 2024; Kumari et al., 2026).

Public discussion of poor-quality medicines nevertheless suffers from conceptual and evidentiary problems. Terms such as *fake*, *counterfeit*, *spurious*, *substandard* and *falsified* are frequently treated as interchangeable, although they describe different regulatory problems. Aggregate test failures are also sometimes interpreted as evidence of deliberate falsification without considering the cause of failure or the method by which samples were selected. Hodges (2019), for example, demonstrates how public narratives surrounding "spurious drugs" may diverge from the regulatory and evidentiary character of cases. Khan and Khar's (2015) review likewise found substantial variation in definitions and prevalence estimates across Indian studies.

Much of the literature has concentrated on prevalence, pharmaceutical quality, technical detection, falsification or individual regulatory failures. Less attention has been given to the administrative question connecting these problems: what capacities must a multilevel regulatory system possess to translate pharmaceutical standards into reasonably consistent outcomes across jurisdictions? This question is particularly important in India because regulatory functions are distributed between the Union and state governments. State authorities undertake major responsibilities for manufacturing and sale licences,

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inspection, sampling and enforcement, while CDSCO regulates areas assigned to the Central Government and performs coordinating and standard-setting functions.

The paper therefore approaches pharmaceutical quality primarily as a problem of Public Administration. It asks: (RQ1) How is pharmaceutical quality governed institutionally and administratively in India? (RQ2) How do weaknesses in regulatory, analytical, coordination and delivery capacity affect control of substandard, spurious and falsified medicines? (RQ3) To what extent do recent reforms address these weaknesses, and what implementation gaps remain?

The argument is deliberately qualified. Decentralization is not intrinsically a regulatory defect. In a large federal system, distributed enforcement can provide local knowledge and administrative reach. The critical issue is whether decentralized authority is supported by adequate and sufficiently comparable institutional capacity, common standards, information interoperability and mechanisms for coordinated action. The paper contributes to pharmaceutical-governance scholarship by interpreting quality control through this capacity-based understanding of multilevel administration.

2. Conceptual and Theoretical Framework

2.1 Distinguishing pharmaceutical-quality problems

Terminological precision is essential because different failures require different regulatory responses. The World Health Organization (WHO) defines a substandard medical product as an authorized product that fails to meet applicable quality standards or specifications. A falsified medical product deliberately or fraudulently misrepresents its identity, composition or source. WHO adopted "substandard and falsified medical products" as its preferred terminology in 2017, partly to separate public-health concerns from intellectual-property disputes associated with the term "counterfeit" (WHO, 2017, 2025).

Indian legislation employs a separate category. Section 17B of the Drugs and Cosmetics Act, 1940 defines circumstances in which a drug is considered spurious, including imitation or substitution of another drug, use of a fictitious manufacturer's identity, substitution of ingredients and false representation of the manufacturer.

Not of Standard Quality (NSQ) has a different administrative meaning. An NSQ finding establishes that a tested sample does not satisfy prescribed quality specifications. Failure may involve assay, dissolution, contamination, stability or other specifications and does not, without additional evidence, establish fraudulent intent. This distinction has practical consequences. Manufacturing-related NSQ failures may primarily require inspection, corrective action, quality-system improvement and recall. Deliberate falsification or statutory spuriousness may additionally require intelligence gathering, supply-chain investigation and criminal enforcement.

For this reason, the revised title does not use "counterfeit" as a general category. Conceptual precision improves not only terminology but also regulatory diagnosis.

2.2 Regulatory capacity

The paper adopts regulatory capacity as its principal analytical framework. Lodge and Wegrich (2014) distinguish several capacities required for effective public problem-solving. Four are especially relevant here.

Regulatory capacity concerns the ability to establish, inspect and enforce standards. Analytical capacity concerns the ability to generate and interpret evidence through laboratories, sampling, data and risk assessment. Coordination capacity concerns information exchange and collective action among authorities whose responsibilities intersect. Delivery capacity concerns the ability to translate regulatory decisions into effective corrective action, including recalls and enforcement.

Black's (2008) account of polycentric regulation complements this framework. Pharmaceutical governance in India is conducted through multiple institutional sites rather than a single regulatory authority. CDSCO, state regulators, licensing authorities, government laboratories, manufacturers and supply-chain actors all participate. Polycentricity can distribute knowledge and enforcement capacity, but it may also produce inconsistency where responsibilities overlap without comparable capabilities, timely information or clear accountability.

The four capacities therefore provide the analytical structure through which the empirical evidence is interpreted rather than functioning merely as introductory theory.

3. Methodology

The study uses qualitative documentary and secondary-data analysis. Its initial literature corpus consisted of 54 Scopus-exported records supplied for the study. Titles, abstracts and bibliographic information were screened for relevance to medicine quality, pharmaceutical regulation, regulatory institutions, inspection, surveillance, enforcement, falsification, pharmacovigilance, supply-chain integrity and India. Ten records were retained for direct use in the final analysis. Technical studies concerned primarily with chemical authentication, unrelated adulteration, engineering prototypes or blockchain applications without demonstrated regulatory implementation were excluded.

The Scopus material was supplemented through targeted searches of PubMed and publisher databases and through official repositories of CDSCO, the Ministry of Health and Family Welfare, the Department of Pharmaceuticals, India Code and WHO. Documentary evidence included the Drugs and Cosmetics Act, the 2003 Mashelkar Committee report, the National Drug Survey 2014–16, Drugs Consultative Committee records, sampling and recall guidelines, Schedule M-related material, surveillance data and regulatory announcements available up to 4 September 2026. Recent peer-reviewed studies were added where they directly illuminated regulatory design or enforcement.

Evidence was coded under the four analytical categories of regulatory, analytical, coordination and delivery capacity. Official records were used primarily to establish institutional arrangements, administrative outputs and regulatory changes; peer-reviewed research was used to interpret regulatory performance and limitations. Claims were triangulated where possible.

This study is not presented as a systematic review because the original Scopus search protocol was not used and no PRISMA-type procedure was undertaken. A further limitation is that routine regulatory sampling is generally designed for surveillance and enforcement rather than prevalence estimation. Administrative sampling data therefore cannot automatically be interpreted as representative estimates of medicine quality across the national market.

4. Regulatory Architecture and the Character of the Quality Problem

India's pharmaceutical regulatory structure combines central regulatory functions with substantial state-level implementation. State drug authorities regulate manufacture, sale and distribution through licensing, inspection, sampling, investigation and enforcement, while CDSCO undertakes functions assigned to the Central Government, including regulation of imports and new drugs and coordination with state authorities. The Drugs Consultative Committee provides a statutory mechanism for promoting greater uniformity across jurisdictions.

Concerns about uneven implementation are longstanding. The Mashelkar Committee reported deficiencies in enforcement, staffing and infrastructure among state regulators and recommended substantial strengthening of the regulatory system (Expert Committee on a Comprehensive Examination of Drug Regulatory Issues, Including the Problem of Spurious Drugs, 2003). These findings remain historically significant, but they cannot simply be treated as a description of every state regulator in 2026.

More recent empirical evidence nevertheless demonstrates that divided authority can generate persistent enforcement problems. Brhlikova et al. (2023) examined central initiatives addressing antibiotic fixed-dose combinations that had received state manufacturing licenses without required prior central approval. Their analysis found that regulatory initiatives reduced some problematic formulations but did not remove the underlying enforcement problem: in 2020, many marketed antibiotic FDC formulations remained unapproved or banned. The case is not evidence about NSQ prevalence, but it provides direct evidence of the difficulty of translating central regulatory requirements into uniform outcomes within a divided administrative structure.

The principal national benchmark for medicine quality remains the National Drug Survey 2014–16. Of 47,012 tested samples, 1,850 were NSQ and 13 were classified as spurious, corresponding to reported estimates of 3.16% and 0.0245%, respectively (National Institute of Biologicals, 2016). These figures should be interpreted as historical survey estimates rather than contemporary prevalence.

Current administrative surveillance measures something different. State and Union Territory regulators reported testing 84,874 samples in 2020–21 and 116,323 in 2024–25. In 2024–25, 3,104 samples were reported NSQ and 245 spurious/adulterated (Ministry of Health and Family Welfare, 2026a). These figures demonstrate continuing regulatory detection but cannot establish national prevalence

because regulatory surveillance may deliberately concentrate on products, manufacturers or locations considered higher risk.

International evidence requires similar caution. WHO's estimate that at least one in ten medicines in low- and middle-income countries may be substandard or falsified is not an India-specific figure. Ozawa et al. (2018) estimated a pooled prevalence of 13.6% across selected LMIC studies but emphasized methodological heterogeneity. Smaller Indian field studies, including Bate et al. (2013) and Noor et al. (2024), establish the presence of quality failures within samples or locations, not a stable national prevalence rate.

5. Administrative Capacity and Pharmaceutical-Quality Control

5.1 Regulatory capacity: inspection and uneven implementation

Regulatory capacity depends on more than the existence of legal standards. Authorities must possess sufficient personnel, expertise and institutional continuity to inspect increasingly complex manufacturing systems and act upon non-compliance.

Kadam et al. (2016), studying Maharashtra, documented serious shortages of drug inspectors and gaps in expected inspection activity during the period examined. The study should not be extrapolated to current staffing conditions across India, but it identifies an important administrative mechanism: statutory responsibility may exceed organizational capacity.

Contemporary regulation also requires specialist competence in pharmaceutical quality systems, validation, sterile manufacturing, data integrity and risk management. Maigetter et al. (2015), although examining pharmacovigilance rather than manufacturing inspection, similarly identified problems involving trained personnel, institutional roles and coordination. Ali and Sinha (2024) note broader challenges in ensuring consistent quality, safety and efficacy standards within India's generic-drug regulatory environment.

The appropriate response is therefore not simply to increase inspector numbers. Regulators require continuing professional capacity, specialist deployment and workload standards linked to manufacturing risk. SHRESTH, discussed below, creates an opportunity to make such interstate capacity differences more visible.

5.2 Analytical capacity: sampling, laboratories and evidence

Quality regulation is only as reliable as the evidence supporting it. Analytical capacity includes laboratory infrastructure, sampling methodology, data management and the ability to distinguish different types of quality failure.

The Union government reported in March 2026 that ₹756 crore in central funding had been released under the Strengthening of States' Drug Regulatory System scheme; 19 new drug-testing laboratories had been constructed and 28 existing laboratories upgraded (Ministry of Health and Family Welfare, 2026a). This represents a substantial expansion of physical capacity, but laboratory expansion alone does not answer the question of what products are sampled and for what purpose.

Risk-based sampling and representative sampling perform different administrative functions. Risk-based surveillance intentionally concentrates resources on products or establishments considered more likely to fail and is therefore appropriate for enforcement. Representative surveys are needed when the policy objective is to estimate market-wide prevalence. India should retain both. The National Drug Survey provides a precedent for periodic probability-oriented assessment, while routine surveillance can remain risk-driven.

CDSCO issued regulatory sampling guidelines in February 2024 and revised guidelines in May 2026 (Central Drugs Standard Control Organization [CDSCO], 2024d, 2026). Such standardization can improve comparability across jurisdictions, but its impact should ultimately be judged through sampling quality, laboratory turnaround time and consistency of follow-up rather than issuance of guidance alone.

5.3 Coordination capacity: federal regulation and information flows

Pharmaceutical products move easily across state boundaries, whereas major licensing and enforcement responsibilities remain territorially organized. This makes information interoperability a core regulatory capacity. A defective batch identified in one jurisdiction may already have been distributed elsewhere before testing and enforcement are completed.

The Online National Drugs Licensing System (ONDLS) illustrates both progress and continuing fragmentation. At the 66th Drugs Consultative Committee meeting in June 2025, only 16 States/UTs had

onboarded ONDLS for manufacturing and sale-related licenses, and wider adoption was urged to promote uniformity (CDSCO, 2025). Digital infrastructure can reduce information asymmetry only when participation is sufficiently comprehensive.

The antibiotic FDC evidence reinforces this point. Brhlikova et al. (2023) show how state licensing decisions and central approval requirements became misaligned over an extended period. The problem was not simply absence of rules but difficulty securing consistent implementation across regulatory levels.

Brhlikova et al. (2011) further demonstrate that pharmaceutical regulation operates through relationships of institutional trust. Variation in enforcement or opaque information concerning quality failures can therefore affect confidence in regulators and legitimate producers, not merely bureaucratic efficiency.

5.4 Delivery capacity: recall, enforcement and supply-chain control

Detection has regulatory value only when it produces timely corrective action. After an NSQ or spurious product is identified, authorities may need to trace batches, communicate across jurisdictions, halt distribution, complete recalls, investigate responsibility and take proportionate enforcement action.

CDSCO's 2024 Recall and Rapid Alert System guidelines provide for voluntary and statutory recalls (CDSCO, 2024b). The important administrative question, however, is not whether a recall framework exists but how effectively it performs. Relevant indicators would include time from laboratory confirmation to alert, time to interstate notification, proportion of distributed stock located, proportion recovered, investigation completion and action against recurrent non-compliance.

Differentiated enforcement is also necessary. A batch that fails dissolution specifications because of inadequate manufacturing control does not constitute the same regulatory problem as deliberate substitution or falsification. Grouping all NSQ findings under the label of “fake drugs” obscures causation and may produce poorly targeted enforcement.

Supply-chain changes add another challenge. Lee et al. (2017) identify online medicine markets as potential channels for falsified products to evade conventional oversight. At the same time, Fryze and Naughton's (2025) systematic review indicates that quality failures within legitimate supply chains frequently involve substandard rather than deliberately falsified products. Effective delivery capacity must consequently address both conventional manufacturing failures and illicit distribution.

6. Recent Reforms: From Regulatory Activity to Regulatory Outcomes

Since December 2022, CDSCO and State Drug Controllers have undertaken risk-based inspections of more than 960 manufacturing premises, with more than 860 regulatory actions reported by March 2026, including warnings, stop-production orders and license suspensions or cancellations (Ministry of Health and Family Welfare, 2026b). CDSCO issued formal risk-based inspection guidance in March 2024 to promote greater consistency (CDSCO, 2024a).

Manufacturing requirements have also been strengthened through revised Schedule M. The revised framework introduced stronger requirements concerning pharmaceutical quality systems, quality risk management, validation and GMP. Larger manufacturers became subject to the revised requirements in 2024, while smaller manufacturers received a conditional extension until the end of 2025 (Ministry of Health and Family Welfare, 2025a). The extension illustrates a recurring administrative tension: regulatory ambition must be matched by the technical and financial capacity required for compliance. The Department of Pharmaceuticals' Strengthening of Pharmaceuticals Industry scheme provides support for technological upgrading (Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, 2024).

Digitalization has expanded through ONDLS, SUGAM Labs and publication of monthly NSQ and spurious/adulterated drug alerts. These initiatives may improve traceability and information exchange, but their contribution depends on comprehensive adoption and integration rather than the existence of separate platforms.

The State Health Regulatory Excellence Index (SHRESTH), launched in August 2025, is especially significant for a capacity-based understanding of federal regulation. It benchmarks state regulatory systems through indicators including human resources, infrastructure, licensing, surveillance, responsiveness and digitalization (Ministry of Health and Family Welfare, 2025b). SHRESTH could convert otherwise diffuse interstate differences into measurable administrative gaps. Its value, however,

will depend on whether benchmarking is connected to technical assistance, resource allocation and measurable improvement rather than functioning primarily as ranking.

Traceability requirements are also expanding. QR-code requirements already cover specified major pharmaceutical brands. Amendments announced in June 2026 extend Schedule H2 coverage to vaccines, antimicrobials, narcotic and psychotropic medicines and anticancer drugs (Ministry of Health and Family Welfare, 2026c). The expanded requirements are phased: vaccines, NDPS medicines and anticancer drugs become subject to them from 1 July 2027, while antimicrobials follow from 1 July 2028. Their effectiveness therefore cannot yet be assessed.

These reforms demonstrate increased regulatory activity and capacity-building, but activity is not equivalent to outcome. Inspection numbers, enforcement orders, laboratories and digital portals are output indicators. Evidence of regulatory effectiveness would require reduced repeat violations, faster corrective action, stronger recall completion, greater convergence in state capability and periodically updated representative evidence of market quality.

7. Discussion and Policy Implications

The findings support a qualified version of the paper's central argument. India's pharmaceutical-quality problem is partly a matter of manufacturing compliance and criminal enforcement, but regulatory outcomes are also shaped by four interconnected administrative capacities.

Regulatory capacity requires adequate and specialised inspection capability across states. SHRESTH should therefore be linked to minimum operational benchmarks for regulatory staffing, inspection workload, specialist expertise and enforcement timelines. Benchmarking should identify where capacity support is needed rather than simply ranking jurisdictions.

Analytical capacity requires a dual surveillance model. Risk-based sampling should remain central to enforcement, while nationally representative drug-quality surveys should be repeated periodically. Keeping these functions distinct would improve both enforcement and the accuracy of national prevalence claims.

Coordination capacity requires genuinely interoperable Centre–State information infrastructure. ONDLS, laboratory systems, monthly alerts and licensing information should progressively support batch-level exchange concerning manufacturers, NSQ findings, recalls, interstate distribution and repeat violations.

Delivery capacity should be measured through outcomes. Recall reporting should include timeliness, geographical reach, stock recovery and closure of corrective actions. Enforcement should also distinguish accidental quality deviation, recurrent manufacturing failure, data-integrity violations and deliberate falsification, with escalation proportionate to cause and risk.

These proposals favor coordinated federalism rather than wholesale centralization. State regulators retain essential local responsibilities and knowledge. The central regulatory system can add greatest value by setting common minimum expectations, building interoperable information systems, providing specialist support and monitoring whether decentralized enforcement produces sufficiently consistent outcomes.

The analytical implication extends beyond pharmaceuticals. Polycentric systems need not achieve identical organizational structures across jurisdictions; they require sufficient capacity at each critical regulatory node to prevent weak links from undermining system-wide performance. In pharmaceutical governance, the relevant measure of reform is therefore not how many new rules or digital initiatives have been introduced, but whether the system can identify, communicate, correct and prevent quality failures more consistently over time.

8. Conclusion

Pharmaceutical quality in India cannot be understood through dramatic counterfeit cases or aggregate test-failure statistics alone. It is governed through a multilevel administrative system in which standards, licensing, inspection, laboratory analysis, surveillance, recall and enforcement are distributed across institutions.

Available evidence does not justify claims that India's medicine market is dominated by falsified drugs. The National Drug Survey 2014–16 identified a substantially greater NSQ problem than a spurious-drug problem, while contemporary regulatory surveillance records continuing failures without providing a representative estimate of current national prevalence.

The central administrative concern is therefore not decentralisation itself but the capacity supporting it. Historical and recent evidence indicates that differences in enforcement capability, information exchange, analytical systems and regulatory follow-through can affect how consistently formal standards are translated into practice.

Recent reforms represent meaningful movement toward risk-oriented and information-based regulation. Revised GMP requirements, risk-based inspections, strengthened laboratories and sampling, SHRESTH, digital licensing and expanding traceability address identifiable weaknesses. Yet their success cannot be inferred from administrative outputs alone.

A stronger pharmaceutical-quality system requires comparable regulatory capacity across states, reliable analytical evidence, interoperable Centre–State information and measurable delivery of enforcement and recall. The key test of governance is ultimately straightforward: not simply whether defective medicines are detected, but whether the regulatory system can identify them early, communicate the risk quickly, remove them effectively and reduce recurrence.

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