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The variation in mobility levels of motorized vehicles between the city center and villages in the Bokaro district of Jharkhand

*[1]Utkarsha Rani and [2]Dr. Rajeev Ranjan Shrivastava

[1]*Ph.D. Scholar (SRF), PG Dept. of Geography, Ranchi University*
[2]*Assistant Professor, Dept. of Geography, St. Xavier's College Ranchi*

Abstract

The emergence of urban mobility and transportation facilities in cities has raised concerns about the lack of similar advancements in rural areas, particularly in the Bokaro District of Jharkhand. It was assumed that innovation and improved mobility would eventually reach the villages, but this goal is still far from being realized. To gather data on the movement of vehicles from Bokaro Steel City to the villages, a field survey was conducted between March and June 2020. Enumerators were assigned to observe and count vehicles crossing pre-determined checkpoints. Additionally, data on maximum temperature, minimum temperature, humidity, and precipitation were collected from https://www.timeanddate.com. The statistical analysis was performed using the Stata-16 software environment for regression analysis. The results of the analysis revealed that the regression coefficient for vehicle crossings per day from Bokaro Steel City to the nearest town was 8.25090, but this value was reduced to 4.10464 for more distant villages. The p-value was found to be statistically significant, indicating a significant difference in vehicle mobility between towns and villages. Furthermore, the study applied a Poisson regression model to examine the significance of various factors and utilized measures of goodness-of-fit such as deviance and AIC. The findings suggested that maximum temperature and weather conditions had a greater impact on vehicle mobility in towns than in villages. In addition to presenting a vision for future rural mobility, this article also highlights the need for key infrastructure, and institutional vis-à-vis financial changes to facilitate the implementation of new technologies in rural areas. Overall, the research sheds light on the disparities in mobility and transportation between urban and rural areas in the Bokaro District. It emphasizes the significance of addressing these disparities and implementing necessary changes to ensure equitable access to transportation and mobility advancements for all communities.

Keywords: *Differential mobility, trickle-down, motorized vehicles, Poisson regression, AIC.*

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***Author's Correspondence**

Utkarsha Rani

Ph.D. Scholar (SRF), PG Dept. of Geography, Ranchi University

utkarshayadav9@gmail.com

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Introduction

The economic growth and development that India has experienced in recent decades have been remarkable, particularly since the restructuring of the Indian economy in the 1990s. However, the development of mobility infrastructure, especially in rural areas, has not kept pace with the demand. In order to ensure sustainable development, it is crucial to take a holistic approach to the topic of mobility, as it plays a significant role in economic growth. Sustainable development relies on the conservation of energy, land, and other natural resources. A state's social and economic status often varies, and energy consumption and production are influenced by the state's population. (Naganathan & et al., 2020). Unfortunately, the market has not adequately provided transport services to areas with low demand, leaving the community's poorest and least mobile segments without reliable transportation options. This results in rural people, especially women, having to travel long distances on foot, carrying heavy loads of water, firewood, grains, and agricultural produce for marketing purposes.

The Sustainable Development Goal Target 11.2 emphasizes the need to provide safe, affordable, accessible, and sustainable transport systems for all individuals, with special attention given to the needs of vulnerable groups such as women, children, persons with disabilities, and older persons (UN-DESA, 2015). Research has extensively documented transportation inequity and its impact on people's lives. Access to transportation determines access to socio-economic opportunities and resources, making it crucial in combating poverty, unemployment, obesity, and other socio-economic problems (Banister & Hall, 1981; Church, Frost, & Sullivan, 2000; Ohnmacht, Maksim, & Bergman, 2009).

Improved transportation connections between urban and rural areas can increase access to employment opportunities in rural areas, thereby reducing development disparities. Rural transport enables people to reach jobs, markets, schools, health clinics, social events, and religious gatherings. It also facilitates the movement of essential goods into and out of rural areas, such as agricultural inputs and food products destined for urban markets. Without proper rural transport, government officials, agricultural extension workers, teachers, health workers, and other service providers would struggle to reach rural residents, and rural residents would face challenges accessing services in nearby towns.

While the focus of this analysis has been on motorized mobility, it highlights the potential for further understanding the relationship between vehicle populations in rural areas. Despite ongoing calls to integrate transportation with land use and regional planning for sustainable development, transportation has largely been considered only in the context of urban development, neglecting its integration into national policies for rural areas. According to Ramaswamy (1998), rural transportation systems should be an integral part of regional planning, connecting towns, large villages, and small villages, representing the nervous system of development planning. However, even after several decades, this aspect remains unaddressed in regional development, particularly in the state of Jharkhand. Furthermore, connected, autonomous, and electric vehicles (CAEV) present an efficient and less disruptive alternative that can be achieved through the integration of existing and emerging technologies in transportation, communication, control, and information processing. This integration can bring about significant improvements in connectivity and transportation systems. (Marsh, 2022)

The present paper aims to address these issues by analyzing the transport system of Bokaro District in Jharkhand, specifically focusing on motorized vehicle mobility from urban to rural areas. The goal of achieving mobility and improved transportation in villages through innovation and advancements is still a distant aspiration in the Bokaro District of Jharkhand.

Study Area

Bokaro district shares its boundaries with Dhanbad district and a portion of West Bengal State to the east, Ramgarh district to the west, Purulia district of West Bengal to the south, and parts of Giridih, Hazaribagh, and Dhanbad districts to the north. Geographically, Bokaro is situated between 23º45' to 23º50'N latitude and 85º30' to 86º03'E longitude. The district's average elevation ranges from 200 to 546 meters above sea level. Covering an area of 259 square kilometers, it is a significant source of medium coking coal in India and is the third coalfield in the Damodar Valley from the east. The region is rich in mineral resources due to its abundant coal reserves and is home to a large labor force. With dedicated efforts, the state can transform its future by improving connectivity and expanding the transportation system to reach the remote villages in the Bokaro district.

In rural areas, Panchayati Raj Institutions (PRI) have evolved over the years and have emerged as crucial organizations for micro-level planning, including the construction and maintenance of rural roads. Recognizing that inadequate road connectivity is a major obstacle to rapid rural development and realizing the potential benefits ranging from poverty reduction to increased employment opportunities in villages, the Government of India launched the Pradhan Mantri Gram Sadak Yojana (PMGSY) in 2000. Despite the emphasis placed on road development plans to enhance accessibility to villages, rural transport infrastructure remains underdeveloped. Nevertheless, the social and economic benefits of rural roads outweigh the costs incurred in their construction. Therefore, improving rural transport connectivity will minimize the likelihood of people in rural areas being left behind in the overall development process.

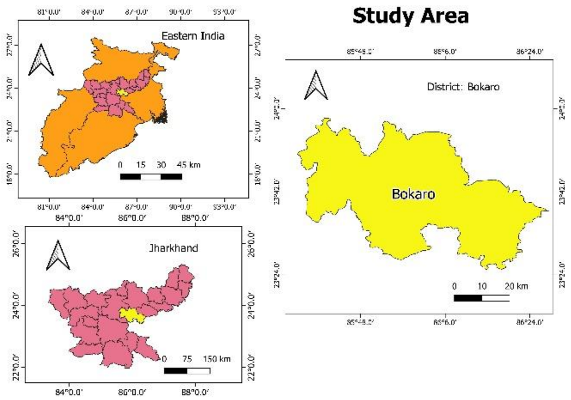

Fig1 (Map prepared by author)

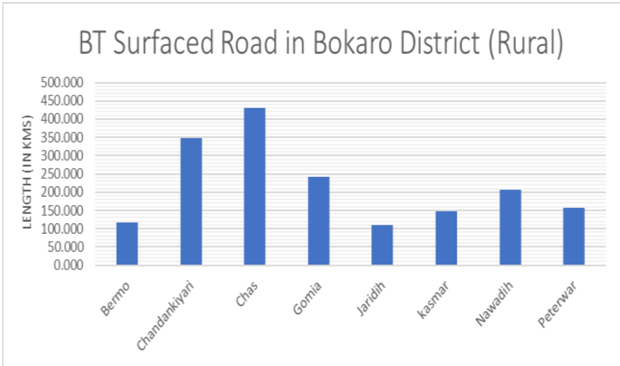

Fig 2 (Source: PMGSY)

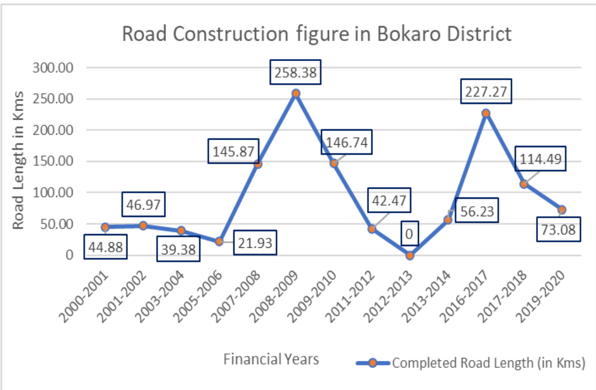

Fig 3 (Source: PMGSY)

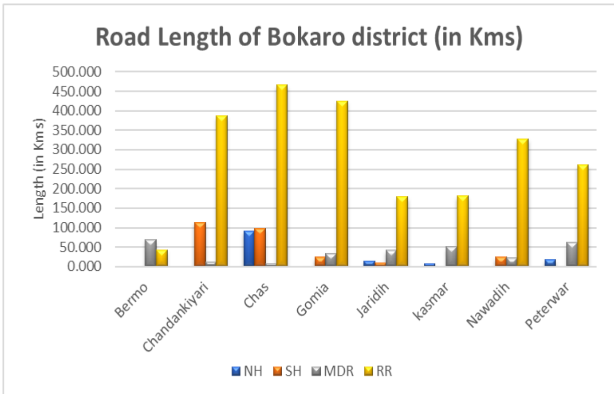

Fig 4 (Source: PMGSY)

Data and Methods

During a field survey conducted between March and June 2020, data on vehicles crossing pre-determined checkpoints from Bokaro Steel City to villages was collected. Enumerators were assigned to observe and count the vehicles using the specified methods. The study also considered various explanatory variables that influence the mobility of vehicles, such as maximum temperature, minimum temperature, humidity, and precipitation. These meteorological data were sourced from https://www.timeanddate.com.

To analyze the data, the researchers employed Stata-16 software and Excel spreadsheets for Poisson regression analysis and ANOVA. Additionally, Q-GIS was utilized for mapping techniques to aid in the analysis. To assess the goodness of fit, separate calculations were made for the gof (goodness of fit) statistic and the AIC (Akaike Information Criterion) for two different models, each with different degrees of freedom (5 and 3). Ultimately, based on the desirable and satisfactory results obtained from the Poisson regression analysis with 5 degrees of freedom, the findings are further discussed in the subsequent section.

Results and Discussion:

1. Impact of Weather Conditions on Vehicles Commutations:

The tables below show the results of the Poisson regression model of vehicular mobility toward villages from Bokaro steel city with four indicators: maximum temperature, minimum temperature, Humidity, and precipitation. By taking the exponential of the coefficient, you can interpret it as a multiplicative effect on the expected counts. For example, if the coefficient for a predictor variable is 0.2, it means that a one-unit increase in that predictor variable is associated with an expected increase of approximately 20% in the expected counts, assuming all other variables are held constant.

Table 1.1

	Chas		Chandankiyari		Chandrapura	
Indicator	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***
Max. Temp	-0.03*	[-.036 -.027]	-0.01*	[-.012 -.001]	-0.01*	[-.013 -.001]
Min. Temp.	-0.01*	[-.015 -.005]	0.00	[-.003 .008]	0.01	[-.001 .011]
Humidity	-1.76*	[-1.857 -1.668]	-0.07	[-.186 .044]	0.003	[-.121 .122]
Precipitation	1.47*	[1.173 1.764]	0.30	[-.049 .659]	0.12	[-.254 .497]
Intercept	8.25*	[8.135 8.366]	5.85*	[5.698 6.008]	5.66*	[5.491 5.819]

Analyzed by authors

Chas, Chandankiyari, and Chandrapura are around 20 km from Bokaro steel city, and transport facilities and connectivity are regular and effective means. For the Chas block, if the maximum temperature, minimum temperature, and humidity increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.0316, 0.010, and 1.762 units respectively. While the precipitation increases by one point, the difference in the logs of expected counts would be expected to increase by 1.469 units. Similarly, For the Chandankiyari block, if the maximum temperature and humidity increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.01 and 0.07 units respectively. In the Chandrapura block, if the maximum temperature increases by one point, the difference in the logs of the expected count of vehicles would decrease by 0.01 units. While in the case of minimum temperature, humidity, and precipitation increase by one point, the difference in the logs of expected counts would be expected to increase by 0.01, 0.003, and 0.121 units respectively. This means vehicular mobility changes with slightly low temperatures and precipitation, providing ease in summer travel to the nearest distances. The intercept is the Poisson regression estimate when all variables in the model are evaluated at zero, the log of the expected count for Chas is 8.2509 units. (Table 1.1)

Table 1.2

	Jaridih		Peterwar		Bermo	
Indicator	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***
Max. Temp	-0.01*	[-.017 -.000]	-0.02*	[.031 -.004]	-0.02*	[-.035 -.012]
Min. Temp.	0.00	[-.007 .011]	-0.01	[.026 .002]	0.01	[-.001 .023]
Humidity	0.04	[-.135 .223]	0.40*	[.116 .693]	0.06	[-.183 .298]
Precipitation	-0.55*	[-1.102 .011]	-1.32*	[2.187 -.444]	-0.31	[-1.048 .426]
Intercept	5.06*	[4.816 5.294]	4.73*	[4.346 5.109]	4.66*	[4.343 4.980]

Analyzed by authors

Similarly, For the Jaridih block, if the maximum temperature and precipitation increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.009 and 0.545 units respectively. This means vehicles moving towards Jaridih village would decrease with changes in temperature and precipitation. Whereas, for the Peterwar block, if the maximum temperature, minimum temperature, and precipitation increase by one point, the difference in the expected count logs would decrease by 0.018, 0.012, and 0.310 units respectively. In the same way, the results for the Bermo block show, if the maximum temperature and precipitation increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.023 and 0.031 units respectively. This means vehicles moving towards the Bermo block are deflected with an increase in temperature and precipitation. These results from the mid-summer season show the considerable impact of weather conditions on moving vehicles in different directions. (Table 2.1)

Table 1.3

	Kasmar		Nawadih		Gumia	
Indicator	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***	***Coeffi***	***95% C.I***
Max. Temp	-0.03*	[-.041 -.010]	-0.02	[-.038 .002]	-0.01	[-.026 .004]
Min. Temp.	0.01	[-.008 .024]	-0.02*	[-.046 -.002]	-0.01	[-.024 .008]
Humidity	0.47*	[.152 .791]	0.03	[-.402 .470]	0.15	[-.168 .472]
Precipitation	-1.08*	[-2.048 -.113]	-0.26	[-1.556 1.029]	-0.45	[-1.422 .521]
Intercept	4.10*	[3.679 4.529]	4.44*	[3.867 5.008]	4.23*	[3.801 4.654]

Analyzed by authors

For the Kasmar block, if the maximum temperature and precipitation increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.025 and 0.806 units respectively. For the Nawadih block, if the maximum temperature, minimum temperature, and precipitation increase by one point, the difference in the logs of the expected count of vehicles would decrease by 0.018, 0.024, and 0.263 units respectively. For the Gumia block, if the maximum temperature, and precipitation increase by one point, the difference in the expected count logs would decrease by 0.010, and 0.045 units respectively. This means vehicles moving towards Gumia are likely to change with changing these two predictor variables' conditions. (Table 1.3)

2. Impact of demographic conditions on commuting vehicles from the city centre to distant villages.

Table 1.4

Poisson regression				Number of obs	=	9
				LR chi2(3)	=	49490.72
				Prob > chi2	=	0.0000
Log likelihood = -33730.042				Pseudo R2	=	0.4232
Vehicles commuting	IRR	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Working population	1.000007	4.52e-08	146.22	0.000	1.000007	1.000007
Literacy	1.032845	.0013197	25.29	0.000	1.030262	1.035435
Pop density	1.000188	.0000169	11.18	0.000	1.000155	1.000221
_cons	811.3556	60.75789	89.45	0.000	700.599	939.6215

Analyzed by authors

When the IRR is greater than 1, it indicates that an increasing score on the predictor variable is associated with an increased incidence rate. For example, if the IRR is 1.5, it means that a one-unit increase in the predictor variable is associated with a 50% increase in the incidence rate, assuming all other variables are held constant.

For a one-unit increase in the working population, while holding all other variables constant, the rate ratio for vehicle commuting is expected to increase by a factor of 1.00007. This means that the incidence rate of vehicle commuting would be expected to increase by approximately 0.007% for each additional unit in the working population.

Similarly, for a one-unit increase in literacy, holding all other variables constant, the rate ratio for vehicle commuting is expected to increase by a factor of 1.0328. This implies that the incidence rate of vehicle commuting would be expected to increase by approximately 3.28% for each unit increase in literacy.

Likewise, if the population density increases by one unit, while holding all other variables constant, the rate ratio for vehicle commuting would be expected to increase by a factor of 1.0001. This indicates that the incidence rate of vehicle commuting would be expected to increase by approximately 0.01% for each additional unit in population density.

These interpretations align with the concept of rate ratios in Poisson regression, where the rate ratio represents the multiplicative change in the incidence rate for a one-unit increase in the predictor variable, with all other variables in the model held constant. (Table 1.4)

The goodness of fit and AIC: In Table 2.1, the AIC & goodness of fit results for the model are shown by taking maximum temperature, minimum temperature, humidity, and precipitation as predictor variables to know the impact of these weather conditions on the mobility of vehicles from the city to villages in different directions and distances. Below that, in Table 2.2 the same impact is evaluated but with a lesser no. of variables namely maximum temperature and humidity. As the rule says, the lowest AIC value has a good no. of predictors to carry out the analysis forward. Whereas the insignificant probability (>0.05) of deviance and Pearson allows us to select the model but Chas, Chandankiyari, and Chandrapura which are at the nearest distance show a significance level (< 0.05) but for them, AIC is lower in the case of 5 degrees of freedom. Based on this, the model with explanatory variables max. and min. temperature humidity and precipitation are taken for analysis of the Poisson regression of the vehicle's mobility individually toward a different direction.

(i)Test of Akaike's information criterion and goodness of fit: A model with max & min temp., humidity, and precipitation.

Table 2.1

Village Destination	N	ll (null)	ll (model)	df	AIC	Deviance goodness-of-fit	Prob>chi²	Pearson goodness-of-fit	Prob>chi²
Chas	109	-2388.045	-1278.108	5	2566.215	1684.627	0.0000	1713.43	0.0000
Chandankiyari	109	-824.049	-818.128	5	1642.275	817.206	0.0000	781.6867	0.0000
Chandrapura	109	-577.7971	-574.625	5	1155.25	341.9567	0.0000	322.3795	0.0000
Jaridih	109	-414.4093	-409.6101	5	829.0203	95.38936	0.7149	93.03605	0.7710
Bermo	109	-545.9963	-535.72	5	1077.44	415.2433	0.0000	366.451	0.0000
Gumia	109	-371.099	-358.1119	5	726.2239	120.6307	0.1266	122.5722	0.1032
Peterwar	109	-394.921	-351.9118	5	713.8237	86.66196	0.8905	87.24775	0.8817
Kasmar	109	-370.4024	-347.6656	5	705.3312	100.2939	0.5846	101.7938	0.5429
Nawadih	109	-324.8033	-294.238	5	598.4761	60.43714	0.9998	59.92898	0.9998

Analyzed by authors

(ii)Test of Akaike's information criterion and goodness of fit: A model with maximum temp. and humidity.

Table 2.2

Village Destination	N	ll (null)	ll (model)	df	AIC	Deviance goodness-of-fit	Prob>chi²	Pearson goodness-of-fit	Prob>chi²
Chas	109	-2388.045	-1333.24	3	2672.48	1794.892	0.0000	1794.892	0.0000
Chandankiyari	109	-824.049	-816.260	3	1642.521	813.4708	0.0000	778.9092	0.0000
Chandrapura	109	-577.7971	-573.120	3	1156.242	338.948	0.0000	319.851	0.0000
Jaridih	109	-414.4093	-411.530	3	829.0607	99.22982	0.6661	96.94651	0.7238
Bermo	109	-545.9963	-533.802	3	1077.605	411.4078	0.0000	363.2898	0.0000
Gumia	109	-371.099	-359.019	3	724.0396	122.4464	0.1311	124.5557	0.1053
Peterwar	109	-394.921	-357.750	3	721.5018	98.34007	0.6891	98.96173	0.6731
Kasmar	109	-370.4024	-350.486	3	706.972	105.9347	0.4835	108.6241	0.4112
Nawadih	109	-324.80	-296.77	3	599.5527	65.51376	0.9993	64.52998	0.9995

Analyzed by authors

Afterward, to compare the means of vehicular mobility, particularly in every direction from the city Anova test results were generated. Table 3.1 shows that vehicles moving towards Chas have the highest average value of 490.24 but also the highest variance (17870.13). whereas for Kasmar and Nawadih 37.87 and 20.62. If the F statistic in the table is greater than the critical F value and the p-value associated with the test is smaller than the chosen significance level ($\alpha = 0.05$), we reject the null hypothesis of the one-way ANOVA. This provides sufficient evidence to support the conclusion that the group means are not all equal. This shows the distribution of vehicular mobility in various directions emerging from the city center to villages with a huge gap depending on the vicinity of the city center to the destination which in this case is a rural area.

Table 3.1

SUMMARY

Groups (towards the village)	*Count (Days)*	*Sum*	*Average*	*Variance*
Chas	109	53437	490.2477064	17870.13252
Chandankiyari	109	32232	295.706422	2172.264866
Chandrapura	109	28729	263.5688073	799.8586476
Jaridih	109	13317	122.1743119	115.9600748
Bermo	109	7377	67.67889908	237.4607543
Gumia	109	4150	38.0733945	52.14271152
Peterwar	109	5062	46.44036697	72.23020727
Kasmar	109	4128	37.87155963	52.0574244
Nawadih	109	2248	20.62385321	22.51461094

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Groups	22878486.6	8	2859810.825	1203.02652	0	1.947912497
Within Groups	2310619.156	972	2377.180202			
Total	25189105.76	980				

Analyzed by authors

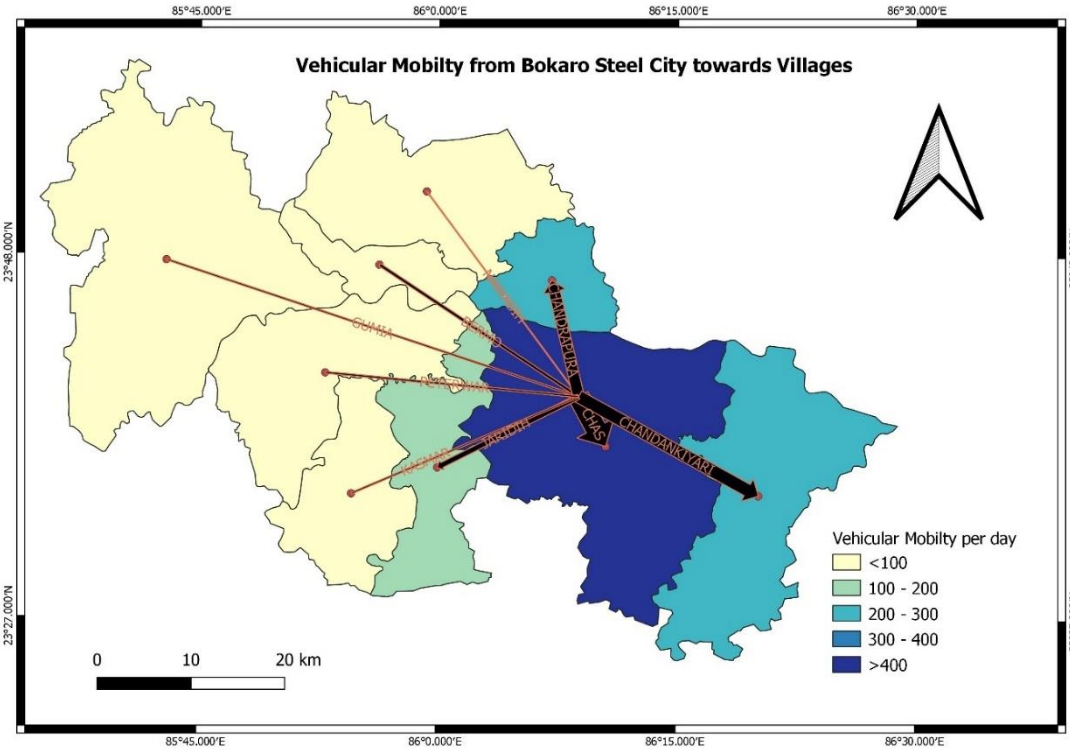

Fig 3 Showing Daily Average Vehicles moving towards different directions (Map prepared by Author)

Table 3.2 shows the types of vehicles and their volume in the entire district from urban to rural areas based on sample data. As we can see that the Two wheelers have had the highest average mobility (9397.66) in three months but they also had the highest variance in exam scores (112076116.5). Below that, the table provides us with several useful pieces of information, the most important value in this table is the p-value which turns out to be **0.00341972**. Since the p-value is less than (α = .05) we reject the null hypothesis of the one-way ANOVA and conclude that we have sufficient evidence to say that not all the group means are equal. This means that the five types of vehicles do not have equal means of distribution in terms of mobility. Two-wheelers are the most important means of communication compared to others and the least availability of buses is pretty much visible in this table.

Table 3.2

SUMMARY

Groups (Types of Vehicles)	*Count (Blocks)*	*Sum*	*Average*	*Variance*
2 Wheelers	9	84579	9397.666667	112076116.5
3Wheelers	9	15699	1744.333333	1250332
4Wheelers	9	21353	2372.555556	4531251.528
Transport Vehicles	9	8848	983.1111111	595534.8611
Fright Vehicles	9	11739	1304.333333	1460543

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Groups	447435085.7	4	111858771.4	4.664133404	0.003481972	2.605974949
Within Groups	959310223.1	40	23982755.58			
Total	1406745309	44				

Analyzed by authors

Conclusion:

From the above study, it can be concluded that:

1. When rural areas have better transport facilities, there is generally less migration observed.

2. Vehicular mobility during the summer season is significantly affected, likely due to the limitations of long-distance rides in high temperatures, especially on two-wheelers.

3. The duration of urban-to-rural mobility in 109 days appears to be relatively low, but there are multiple factors contributing to this situation, and it cannot be solely attributed to improved transport connectivity.

4. While the region is rich in coal resources and has well-established connections for transporting raw materials and steel plant outputs, there is a lack of rural transport networks and comprehensive development plans.

5. The focus should be on transforming villages by establishing connections with urban nodes and centers, facilitating the movement of people between rural and urban areas.

6. Public transport is crucial in rural areas to bridge the gap between urban and rural communities, as private vehicles, particularly two-wheelers, serve as the primary mode of transport due to the absence of adequate public transportation options.

7. In some areas, village roads are not properly constructed, further hindering transportation.

8. The Pradhan Mantri Gram Sadak Yojana (PMGSY), aimed at connecting villages with all-weather roads, is an admirable effort.

9. It is necessary for the urban and rural departments to collaborate financially and technically to develop a comprehensive master plan for transport route connectivity and effective management.

In summary, the passage underscores the significance of enhancing transport infrastructure, improving public transportation, and strengthening connectivity between urban and rural areas to foster overall development and facilitate efficient mobility.

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Author's Biography:

Utkarsha Rani *is currently pursuing Ph. D. from Ranchi University under UGC-NET/JRF scheme. She has completed her graduation & post-graduation from St. Xavier's College, Ranchi. Her area of Interest is Urban planning and Development as well as Human Development along with a special interest in Remote Sensing and GIS for Land use Landcover Analysis. She has published a few Research Articles, one of them being Emerging Cities and Urbanization in Jharkhand.*

Dr. Rajeev Ranjan Shrivastava *has been teaching at St. Xavier's College, Ranchi for the past 22 years and is also working as a research supervisor on several social-science arenas with more than 5 Research Scholars. He is currently teaching at the same campus, on regional planning as well as several other graduate & postgraduate courses focusing on agricultural geography and Environment and planning. His previous contribution to the field of research includes "Land-use land cover change of Ramgarh District" Born in Ranchi, then Bihar Dr. Shrivastava went to St. Aloysius High School, Ranchi, and graduated from St. Xavier's College with an undergraduate honor's degree in chemistry. Afterward, he got selected into the prestigious Centre for the Study of Regional Development, JNU, and pursued his master's as well as M.Phil. from the same. Then after he earned his Doctor of Philosophy and got published his book on 'Emerging Trends of Cropping Pattern in India.' His visionary perspective led him to work on "Granitic rocks of Ranchi" presented at Aswan, Egypt in 2013. He has delivered several lectures at various institutes such as Sri Krishna administrative training Institute, Academic staff college Ranchi University, G.B. Pant social science Institute, and Praygraj on various subjects of his interest. He currently has more than 20 publications in National and International Journals. He is presently an active member of the National Associations of Geographers India (NAGI), The Goa Geographer (A peer-reviewed journal), Association of Professional Geographers of India (APGI), Association of Geographers Bihar and Jharkhand (AGBJ). His area of interest includes Agricultural Geography, Urbanization, Environment, and Regional Planning at Development.*

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