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Assessing the Impact of Metro Construction Work Zones on Daily Commuters: A Case Study of Patna Sadar Block

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Abstract: *The paper analyses the introduction of Patna Metro as a public transport system. Patna Metro is an electric-based mass rapid transit system. This massive project is now in its construction phase. It analyses how construction activities have affected the pollution level and the problems faced by daily commuters. It explores the possible effects of the Patna Metro project on auto rickshaw drivers, assessing how it might affect their daily wages, employment, passenger volume, and overall opportunities. The investigation also includes a close examination of the project's route map and an evaluation of the efficiency of the sustainable management strategies used by the Metro authority. It anticipated long-term impacts of the project on other modes of transportation and the potential shifts in vehicle usage patterns. The Patna Metro is seen as a major milestone in the development of Patna City, significantly contributing to the reduction in accident rates, fuel savings, and atmospheric pollution .This study makes important policy recommendations for the ongoing metro project to internalize commuter-related negative externalities.*

Keywords: *Sustainable management, Construction work zones, Long term impacts, Urban transport system, Daily commuters.*

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Introduction:

Patna, the capital of Bihar with an estimated population of 2.58 million has now become the 19th largest (in terms of population) city in India. According to the study, the population of Patna has been increasing at an alarming rate. Because of this, there has been greater pressure on the existing natural resources, leading to the problem of traffic congestion and pollution which further inhibits the growth of Patna as a city.

The infrastructural development projects (in terms of providing an efficient means of transportation) is one such way to tackle this problem. The introduction of MRTS (Mass Rapid Transit System) in Patna has provided us an efficient way to address issues such as pollution, traffic congestion, etc. thus reducing traffic congestion and ensuring a clean and sustainable environment.

But the construction of metro is inevitably accompanied by considerable environmental impacts (Sharma et. al., 2013) such as pollution, traffic congestion (at the time of construction). Moreover, metro during its construction phase has aggravated the problem of pollution further leading to severe health issues and other deadly diseases.

So, this paper analyses the issues or the problems that are caused during metro construction (mainly pollution), covering environmental and other aspects.

Reviews of Literature:

M. Kumar (2003) analyses all potential solutions that will help in minimizing the negative environmental affects that are involved during the planning and implementation of metro projects in a highly polluted city.

R. Hemasree, C.V Subramanian (2008) stated that how decrease in air pollution; time savings for passengers; decrease in accidents; decrease in traffic congestion and fuel savings bring an influence on the socio-economic position of commuters.

Niraj Sharma, Rajni Dhyani, S. Gangopadhyay (2013) explained in their research paper about the construction of the metro rail system and several important issues such as environmental, social and other related critical issues.

Delhi Metro Rail Corporation (2020) assess the environmental impact of metro construction rail project in Patna.

Ravi Bhutani, Dr. Sewa Ram, Dr. Kayitha Ravindra (2016) gives us an account of the impact of metro rail construction work zones on traffic environment and assess or evaluate the unaccounted direct and indirect economic loss caused during the metro construction by construction work zones.

Objectives:

- To analyze the route map of the project.
- To assess the impact of metro construction on auto-rickshaw drivers.
- To investigate the problems of traffic congestion faced by daily commuters.
- To examine the change in pollution level.

Research Methodology:

Area of Study: Gandhi Maidan, Patna, Bihar

Sources of data: The sample size of data is 54. Also 30 samples were taken from auto-rickshaw drivers.

Primary Data - Primary data from (Daily Commuters) which includes Rickshaw Pullers, Auto Rickshaw drivers, People who travel on foot, students of schools and colleges and office bearers etc.

Primary has been collected from social survey, field visit, discussion with affected people.

Secondary Data - Secondary data has been collected from research paper, gazette, relevant text and internet etc.

Methods of Analysing Data:

Research design will be based on simple random sampling data from each sample collected which will be organize through well-structured interview method.

The data will be analysed by Bar Graph, Pie Charts, Tables, Columns and Statistical tools.

The Statistical tool includes:

- T-test
- Chi-square test

Results and Discussion:

1. COMPARATIVE ANALYSIS BETWEEN AQI (AIR QUALITY INDEX) OF GANDHI MAIDAN AND RAJBANSHI NAGAR:

Comparative analysis between AQI of Gandhi Maidan before and during Construction:

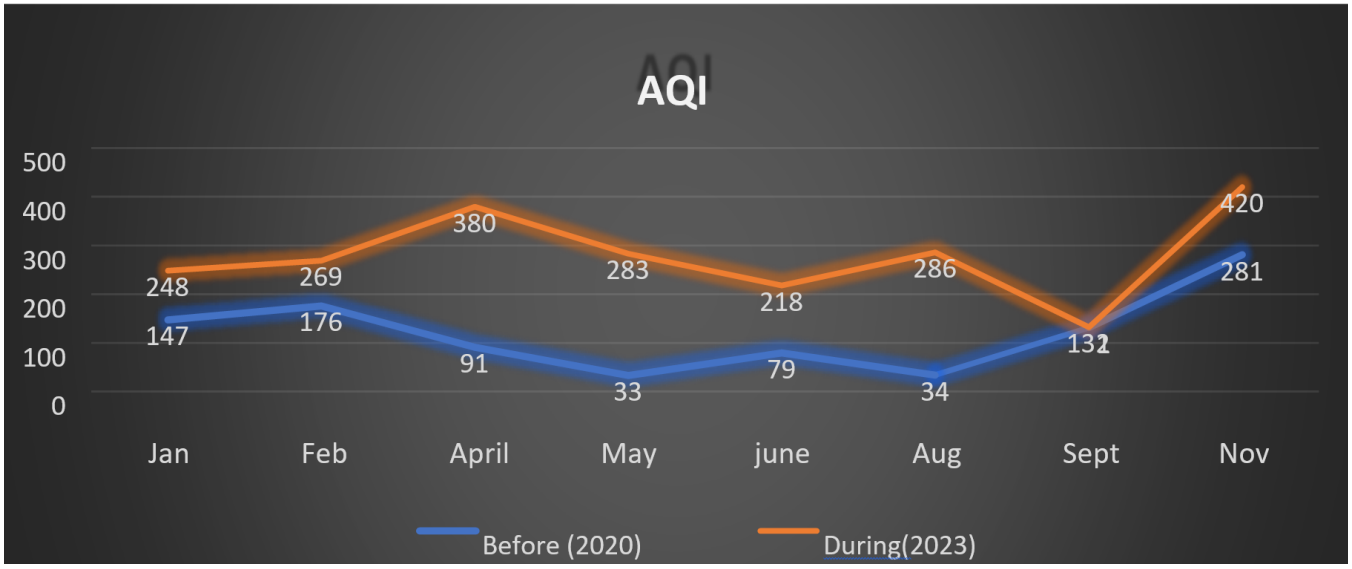
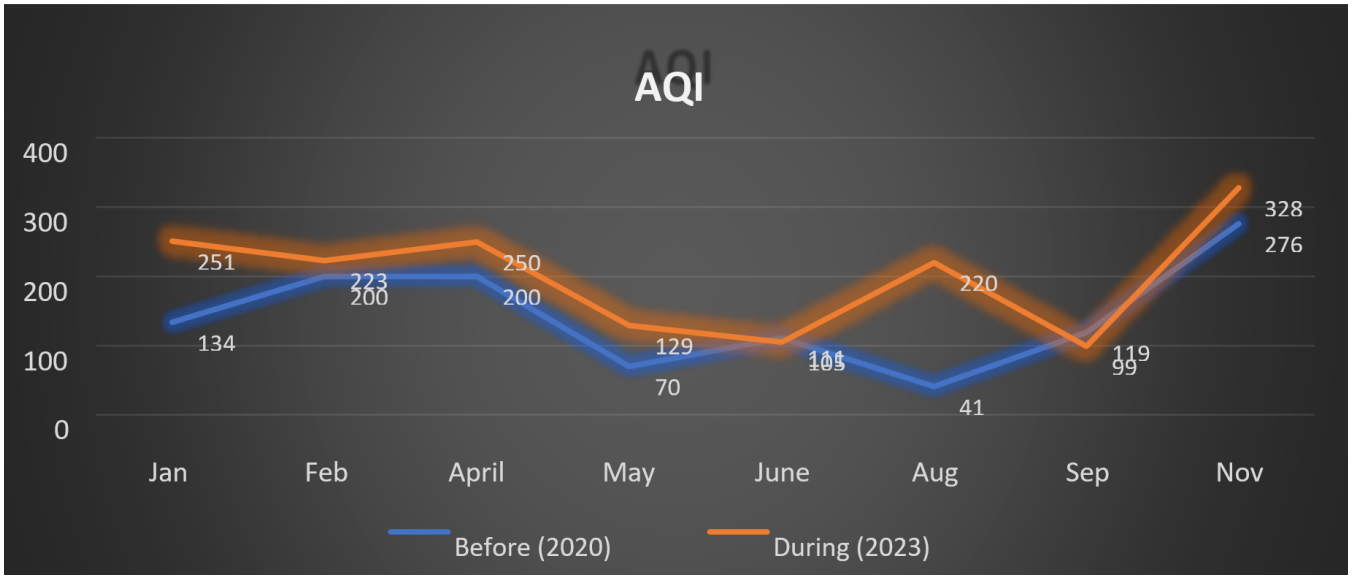


Fig. 1

Comparative analysis between AQI of Rajbanshi Nagar before and during Construction:



In the Fig. 1, the Air Quality Index (AQI) for Gandhi Maidan has noticeably increased from before (2020) to during construction (2023), indicating a deterioration in air quality. However, in Fig. 2, the AQI for Rajbanshi Nagar shows relatively minor changes during this time period. This comparative analysis suggests that construction activities may have contributed to the worsening air quality specifically at Gandhi Maidan, while Rajbanshi Nagar experienced less impact.

Comparative analysis between AQI of Gandhi Maidan and Rajbanshi Nagar:

Pre-Construction phase: The 2020 AQI data for Gandhi Maidan and Rajbanshi Nagar shows fluctuations all year long. The series has some noticeable gaps because certain observations were missed.

Despite this, the seasonal pattern for PM 2.5 and PM 10 is evident, with winter (November through January) seeing greater levels than the summer (April to August).In 2020, Rajbansi Nagar's AQI surpasses that of Gandhi Maidan. The difference first widens between April and July, after which it becomes apparent that the AQI levels in the two places were nearly identical. The 2020 AQI levels in both the metropolitan area and non-metropolitan were notably better prior to the construction period, indicating a decline in air quality in Patna in recent years. Comparing the average concentration with national air quality standards from the CPCB, all values remain below the prescribed limit, falling within the "good" (0-50) and "satisfactory" (51-100) categories.

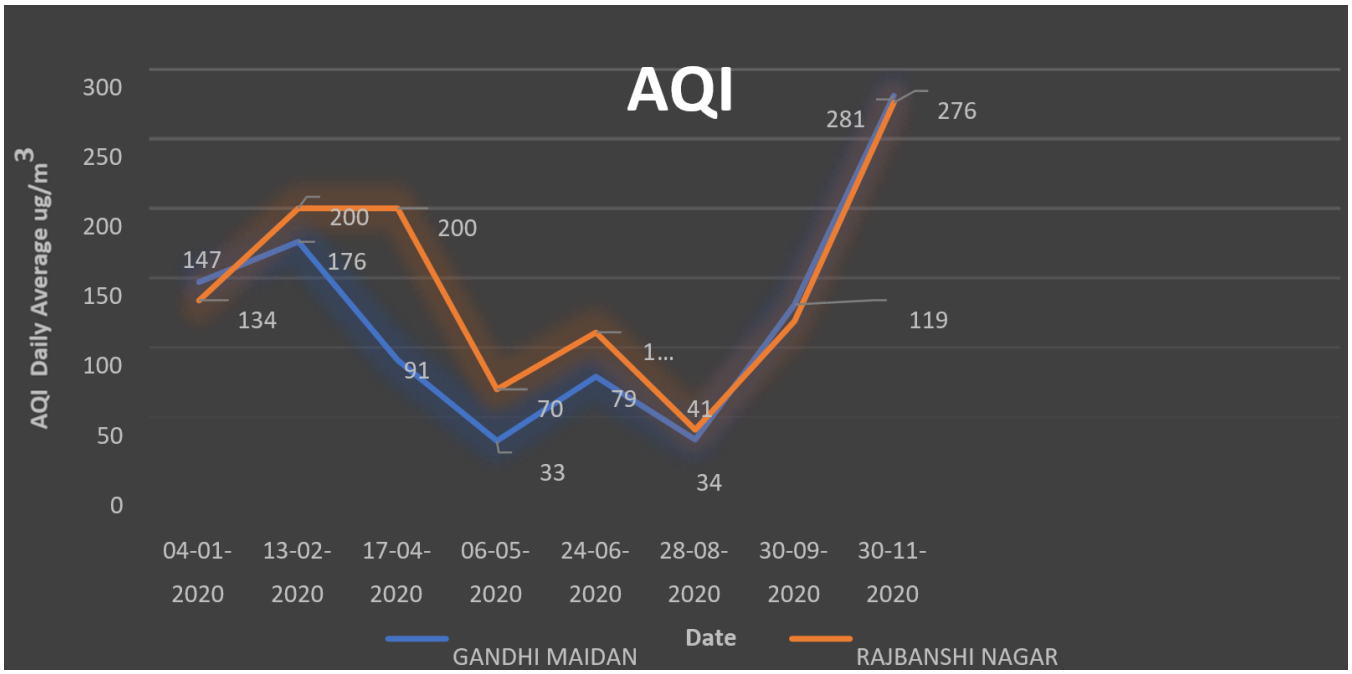


Fig. 3

The analyzed AQI data for Gandhi Maidan and Rajvanshi Nagar in 2020 indicates variation throughout the year. There are some noticeable gaps in the series due to missing observation. In spite of this, we see a clear picture of the seasonal pattern for PM 2.5 and PM 10, with their levels being higher in winter (November through January) than in summary (April to August).The AQI of Rajbanshi Nagar is more than Gandhi Maidan in the year 2020. Initially the gap enlarges from April to July and then it can observed that both areas have almost same AQI level.

During Construction Phase: The 2023 AQI data analysis for Gandhi Maidan (Metropolitan area) and Rajbanshi Nagar (Non-metropolitan area) reveals fluctuations throughout the year. The AQI of Gandhi Maidan is higher than that of Rajbanshi Nagar, contrary to the pre-construction period in 2020. The disparity widens during the summer season. Both areas show a decline in air quality from 2020 to 2023, but Gandhi Maidan's air quality worsened during this period. The annual average AQI increased from 121 to 272 in Gandhi Maidan. When comparing average concentrations with the national air quality standards from CPCB, all values in Gandhi Maidan exceeded the prescribed limit, falling within the poor (201-300) and very poor category (301-400), while in Rajbanshi Nagar, all values fell within the moderate (101-200) and poor category (201-300). A seasonal pattern can be observed in Rajbanshi Nagar, but it is absent in Gandhi Maidan. Our study indicates that the major pollutant in Gandhi Maidan is particulate matter, suggesting that it arises from construction activity and unregulated traffic.

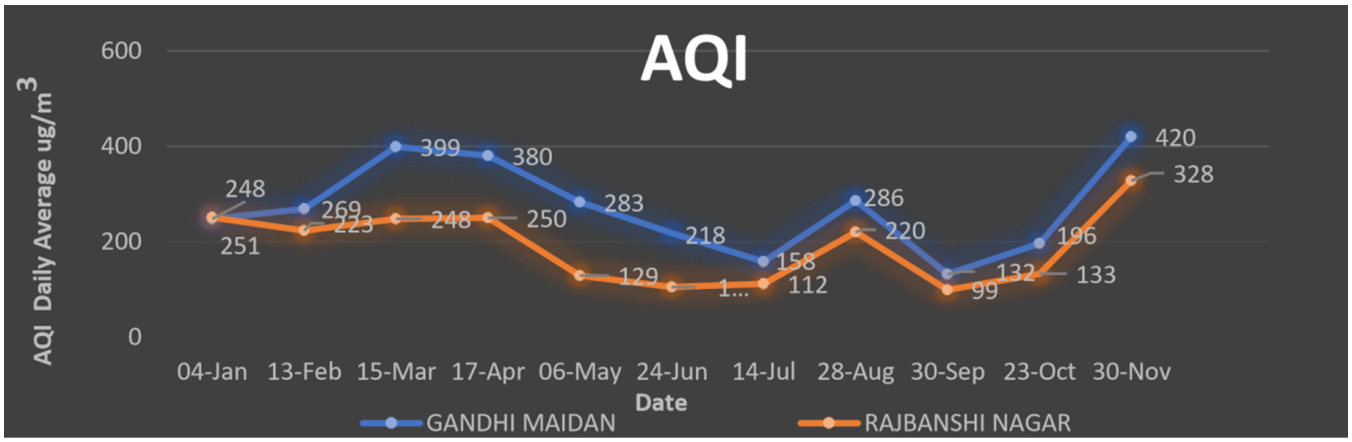


Fig. 4

Result: The AQI (Air Quality Index) of Gandhi Maidan is found to be higher than the AQI of Rajbanshi Nagar.

2. RESPONSES BY COMMUTERS:

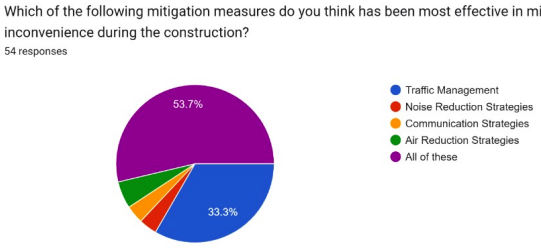


Fig. 5

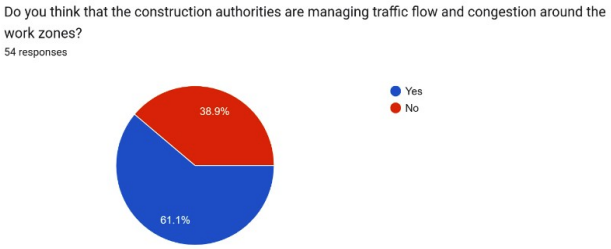


Fig. 6

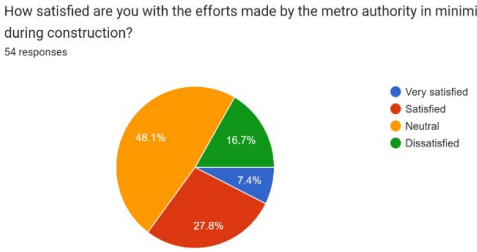


Fig. 7

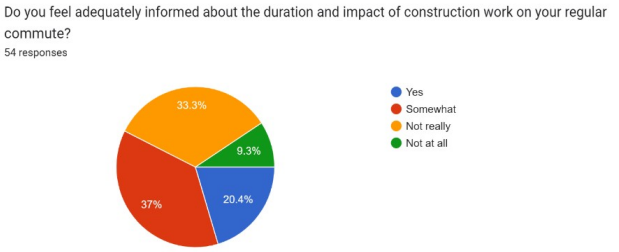


Fig. 8

In our research, we conducted a survey in which we have recorded the responses of commuters such as their usual mode of travelling in which about 75.9 percent respondents prefer auto, 7.4 percent prefer bike and 5.6 percent who prefer bus and other modes of transportation each respectively and also we have recorded their usual purpose of travelling, how frequently they commute through construction work zones, about communication channels through which they receive information regarding metro construction, and also how satisfied are those commuters by the communication efforts made by metro authorities, we also asked whether you have ever attended public meetings or forums to discuss about the mitigation measures in which 5.7 percent respondents were attended and 94.3 percent were did not attend any meetings or forums organised by the metro authorities, we also asked about which mitigation measures would be the most effective, commuters were also asked whether the construction authorities are able to manage the traffic flow and congestion or not in which about 61.1

percent of the respondents were agreed and about 38.9 percent were disagreed with the statement, we have also recorded that whether they are satisfied with the efforts made by the metro authorities or not, we also asked how much information is available about duration and impact of construction work, and we have also taken a question regarding the clarity of information provided by the metro authority about alternative routes or changes due to construction work in which 33.3 percent of the respondents have rated good, 46.3 percent have rated fair and 18.5 percent have rated poor accordingly.

3. IMPACT ON AUTO-RIKSHAW DRIVERS

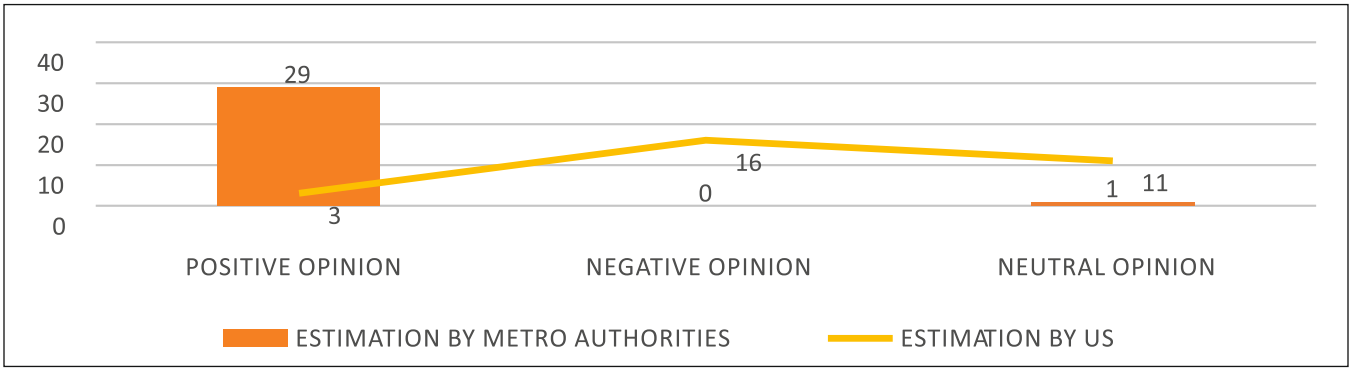


Fig. 9

Out of 30 auto-rickshaw drivers who answered this question:

- 11 auto-rickshaw drivers are of neutral opinion
- 16 drivers were of negative opinion
- 3 drivers were of positive opinion

4. LONGTERM IMPACT OF PATNA METRO PROJECT

While there may be short-term difficulties and disruptions due to the construction of a new metro, society will ultimately profit greatly in the long run.

1. Shift in Passenger's Daily Trip

Table 1.

Mode	Trips Without Mass Transport System				Trips with Mass Transport System			
	2024	2031	2041	2051	2024	2031	2041	2051
Bus	185218	216178	240699	268000	93897	91671	116870	129423
Car	284950	361683	421223	479308	208662	211617	269795	298847
Two Wheeler	997327	1259655	1527511	1803847	600375	609660	736174	808904
Auto	854851	1039320	1203493	1391539	556431	564313	719453	809878
Taxi	32057	45730	60175	67000	10433	7024	8952	9884
Metro	-	-	-	-	884603	1438281	1601856	1952757
Total	2354403	2922566	3453100	4009695	2354403	2922566	3453100	4009694

Source : DPR (Detailed Project Report)

The provided tabular data illustrates the variation in daily passenger journeys made with and without Patna Metro. The total number of daily journeys is projected to reach 23,54,403 in 2024 and 40,09,695 in 2051. There has been a roughly 70% increase. An important component of this increase is the Patna Metro project. 8,84,603 daily journeys are anticipated to be handled by the Metro project in 2024; by 2051, this number is estimated to rise to 19,52,757.

2. Reduction in CO_2

Table 2.

Mode	Volume of CO_2 emitted (g /kmCO_2)	Annual Vehicle Km saved (Million km)				Annual saved CO_2 emission (t-CO_2)			
		2024	2031	2041	2051	2024	2031	2041	2051
Bus	787.22	7.9	11.1	11.8	13.8	6223	8744	9295	10871
Car	139.52	95.8	168.8	175.9	207.3	13366	23551	24542	28922
2-Wheelers	28.58	737.1	1146.8	1395.2	1735.3	21066	32776	39875	49595
3-Wheelers	77.89	201	316.7	347.9	435.4	15656	24668	27098	33913
Taxi	139.52	12.9	23.5	32.6	38.2	1800	3279	4548	5330
Total		1055	1667	1963	2430	58111	93017	105358	128631

Source: JST calculated through DPR, 2021

According to the data from DPR 2021, the annual vehicle kilometers saved and the volume of pollutants (g/km), including CO_2, for different modes, are shown below. The Patna Metro project is expected to play a major role in saving vehicle kilometers each year. This will increase from 1055 million kilometers in 2024 to 2430 million kilometers in 2051. The reduction in vehicle kilometers will play a significant role in reducing CO_2 emissions. The annual saved CO_2 emissions will increase from 58111 tons (tCO_2) in 2024 to 128631 tons (tCO_2) in 2051. Cars are expected to be the biggest source of saved CO_2 emissions, followed by two-wheelers and buses.

3. Other Impacts:

The implementation of the Patna Metro presents a dual benefit by contributing to fuel savings and reducing air pollution. With fewer cars on the road, the city's overall fuel consumption decreases (Hemasree et. al., 2008), particularly as the metro operates on electricity, curbing tailpipe emissions and lessening greenhouse gases. Additionally, the efficient Metro Rail system promotes shorter travel distances for drivers, enhancing their cost-effectiveness and potentially reducing traffic congestion and accidents. The installation of auto stands at metro stations further supports drivers. While there may be concerns about declining passengers and fare structure.

Assessment of Hypothesis:

The three major hypothesis of our research are:

- There exists a correlation between the construction work zones and pollution level.
- There will be an adverse effect on auto-rickshaw drivers.
- Sustainable management of the construction work zone has positive impact on daily commuters.

[After the assessment of the above mentioned hypothesis, its impact can be summed up as:]

1. There exists a correlation between the Construction Work Zones and Pollution Level: It has been found that greater the extent of construction work zones, higher will be the pollution**.** It is observed that AQI of Gandhi Maidan is higher than the AQI of Rajbanshi Nagar. [by using the statistical tool (t- test)]. We have in our analysis that Gandhi Maidan is a construction work zone and Rajbanshi Nagar is a non-construction work zones. By using the statistical tool t-test, we observe that the AQI level of Gandhi Maidan is higher than the AQI of Rajbanshi Nagar.

T-Test

Date	AQI (Air Quality Index of Gandhi Maidan) 2023	AQI (Air Quality Index of Rajbanshi Nagar) 2023
January, 04	248	251
February,13	269	223
March,15	399	248
April,17	380	250
May, 6	283	129
June, 24	218	105
July, 14	158	112
August, 28	286	220
September, 30	132	99
October, 23	196	133
November, 30	420	328

p VALUE = 0.02105 (using t test)

H0: There is no significant difference in the pollution level of construction work zones and non construction work zones H1: There is a significant difference in the pollution level of construction work zones and non construction work zones

For proving our hypothesis, we apply t-test(using MS Excel). At the 5% level of significance, we find p-value to be 0.02105, which is less than 0.05, so we will reject null hypothesis (Ho).

Hence, we can say that our hypothesis has been proved correct.

Result– This proves that there is a significant difference between the AQI of Gandhi Maidan and Rajbanshi Nagar.

2. There will be an adverse effect on auto-rickshaw drivers : By analyzing the interviews of auto-rickshaw drivers, we attempt to understand the opinions of auto-rickshaw drivers on metro construction. Surveys of drivers are the best way to know about the ground reality of metro construction.

On July 15, 2022, metro authorities had taken interviews at four major auto-rickshaw stands. And on November 25, 2023, we had asked auto-rickshaw drivers about their opinion at Gandhi Maidan stand. At first, the drivers were given general information about the Patna metro project and then asked about their opinion regarding the impact of metro construction on their living.

Responses	Responses Recorded by Metro Authorities	Responses Recorded by Us	Total
Positive	29	3	32
Negative	0	16	16
Neutral	1	11	12
Total	30	30	60

Chi-square test can be used to prove the hypothesis :

HO: There is no significant difference between the responses collected by metro authorities and us.

H1: There is significant difference between the responses collected by metro authorities and us.

CELL	Oi	Ei	Oi-Ei	(Oi-Ei)2	(Oi-Ei)2/Ei
I	29	16	13	169	10.56
II	0	8	-8	64	8
III	1	6	-5	25	4.17
IV	3	16	-13	169	10.56
V	16	8	8	64	8
VI	11	6	5	25	4.17

$X^2 = \sum(O_i - E_i)^2/E_i = 45.46$

Degree of Freedom, v =2

For v=2, p = 0.05, Critical Value of ^{2}=5.99

Since observed value is more than the calculated value, our null hypothesis is rejected.

Thus, there is significant difference between data collected by us and metro authorities.

Hence, with this we can say that there will be an adverse effect on auto-rickshaw drivers.

Therefore, the responses recorded by metro authorities shows that it will have positive impact on drivers which may not be true. So , for now, we can say that construction of metro will adversely affect auto-rickshaw drivers.

3. Sustainable management of the construction work zone has positive impact on daily commuters: It is evident from our analysis that 66.7% of the total respondents frequently commute through construction work zones and 9.3% of the responses monthly commute through construction work zones. According to our survey, we found that the 9.3% of the respondents are very dissatisfied, 27.8% of the respondents were dissatisfied, whereas 40.7% of them were neutral and only 18.5% of the respondents were satisfied by the communication efforts made by the Metro construction authorities regarding the mitigation measures. 35.2% of the commuters were satisfied by the efforts made by the Metro authority in minimizing the inconvenience during construction, but 48.1% of the commuters are neutral and 16.7% are dissatisfied.61.1% of the people say that construction authorities are managing traffic flow and congestion around the work zones, but 38.9% of them gave negative response. Traffic congestion during the metro construction is the major problem faced by the daily commuter. Also, travel time has increased to the some extent. Also, the commuters witnessed deterioration in the air quality around the construction work zone.

Also, the nodal agency for Patna Metro project has taken several measures at its construction site to curb the pollution. But still these problems are faced by commuters.

With this we can prove that our **hypothesis has been proved wrong.**

Recommendations:

1) Systematic work zone and traffic management techniques are required to be implemented by the metro authorities to counter the problems such as pollution and traffic congestion.

2) Safety norms: There should be strict guidelines for workers in the construction work zones so that they follow safety norms, to ensure the safety of the workers.

3) Awareness Program: Metro authority should organise awareness programs to make citizens aware of the benefits and concerns related to metro construction.

4) Realistic Timelines: Time is considered as one of important factor so the authority must establish realistic project timeline that account for potential delay due to unforeseen circumstances, weather, unexpected challenges etc.

5) Initiatives: When Patna metro will be in operation, it may cause adverse effect on present auto rickshaw drivers so government should take some initiatives so that their livelihood should be continue.

Policy Implications:

1) Traffic diversion plans, including barricading of the project site, needs to be implemented in consultation with the traffic police and land authorities before the start of the construction activities. To prevent inconvenience, the public should also be informed well in advance of this diversion or closures.

2) As per our survey, auto-rickshaw drivers voiced concerns about their income and passenger volume due to route overlapping with the upcoming metro lines. As a result, the government ought to provide the required employment possibilities and incentives. Integrating these auto-rickshaws into public transportation requires gaining access to financial services, receiving training, and interacting with policy makers. Drivers of auto-rickshaws must be registered in Patna city. Auto rickshaw should then act as feeders to the city metro rail, charging a minimal price for passenger service. They should be put through training programs, and the Patna Metro Rail Authority should support the implementation of the feeder service by providing parking facilities on the ground.

3) According to the estimation by DMRC (Delhi Metro Rail Corporation), the PMRC (Patna Metro Rail Corporation) in Patna has taken down 911 trees (Corporation,D.M.,2020) during the first and second phases of its construction. For three years, about 3644 saplings would be planted and cared for. Finalizing the

compensatory afforestation program will include working with the tree authorities. Because there isn't enough land to grow new trees, it is always debatable that when trees are cut down at a project site, their compensatory afforestation is done far from the project site on Patna's outskirts. It is preferable and should be involved that afforestation is done as close to the project site as possible, in consultation with the local authorities.

Conclusion:

Amidst Bihar's struggle with the challenges of inadequate infrastructural development, which is a prominent indicator of economic development for a region, the development of Patna metro has emerged as a beacon of progress for the state. However, because of rapid urbanization, the public transport infrastructure, which is now being gradually improved, cannot cope with the increases in the road transport demand, thereby causing a severe traffic congestion and pollution problems. It results in a loss in economy (Bhutani et.al., 2016) and damage to health due to pollution.

Through our study it has been shown how construction work zones are further increasing the pollution level. Also, commuters are of the view that metro construction work zones are increasing the pollution of Patna. So, now it becomes very crucial for us to have systematic work zone to reduce the impact of air pollution in the city. This is because recent studies shows that increase in pollution level even for shorter duration has adverse effect on the foetus in womb to old person (Kumar, 2003). Therefore, by proper planning and execution can minimise the effect of pollution to a large extent.

However, it is believed that the development of metro system in Patna will help in reducing pollution and traffic congestion problems in the city and make Patna a cleaner city. The commuters also felt that the mass rapid transit system will benefit them by costing cheap fares.

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